JUL 5 '45

UNITED STATES DEPARTMENT OF COMMERCE

Journal of Research

of the

National Bureau of Standards

Vol. 34, No. 6 June 1945

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Journal of Research

of the

National Bureau of Standards

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Volume 34, Number 6

June 1945

[Published with approval of the Director of the Budget]

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1945

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A list of the mathematical tables now obtainable from the National Bureau of Standards is printed on pages 3 and 4 of the JOURNAL cover. New tables will be announced from time to time as they become available. An order blank is available on the last page of this issue.

U. S. DEPARTMENT OF COMMERCE NATIONAL BUREAU OF STANDARDS

RESEARCH PAPER RP1656

Part of Journal of Research of the National Bureau of Standards, Volume 34, June 1945

TERM ANALYSES OF THE FIRST TWO SPECTRA OF COLUMBIUM

By Curtis J. Humphreys and William F. Meggers

ABSTRACT

Published wavelengths and estimated intensities of lines characterizing the first two spectra of columbium (RP881) have been supplemented by observations of the arc spectrum (6500 to 8500 A) in an atmosphere of helium, by observations of the spark spectrum (2000 to 2100 A), and by measurements of the Zeeman patterns for 1,557 lines. All available data have been analyzed for the purpose of correcting and extending the information about the structures of Cb II and Cb I (RP793).

The Cb II table contains 1,723 lines (2002.41 to 7026.15 A), 1,494 of which are explained as combinations of 183 ionic energy levels comprising 27 singlet, 40 triplet, and 9 quintet spectral terms. The terms arising from electron configurations $4d^4$, $4d^3\,5s$, and $4d^3\,5p$ have been almost completely established, but efforts to find spectral series for Cb II were futile. The lowest energy (normal state) of Cb^+ ions is represented by $(4d^4)\ a\,^5D_0$, but the strongest emission lines involve $(4d^3\,5s)\ a\,^5F$, a metastable term. The most intense line of the Cb II spectrum is $(4d^3\,5s)\ a\,^5F_4-(4d^3\,5p)\ z\,^5G^\circ_5$, with a wavelength of 3094.172 A. Zeeman patterns observed for 646 Cb II lines were most helpful in extending this analysis, which now includes 87 percent of the recognized lines and 95 percent of their total intensity.

The Cb I table contains 3,313 lines (2164.54 to 10920.7 A), 2,836 of which have been interpreted as combinations of 364 atomic energy levels representing 58 doublet, 55 quartet, and 13 sextet spectral terms. The lowest term (normal state of neutral Cb atoms is $(4d^4\,5s)^6a\,^6D_{0\frac{1}{2}}$, and the strongest line of the Cb I spectrum is the transition $(4d^4\,5s)\ a\,^6D_{4\frac{1}{2}}-(4d^4\,5p)\ y\,^6F^\circ_{5\frac{1}{2}}$, with a wavelength of 4058.931 A. The Cb I spectrum is largely accounted for by transitions between levels arising from $4d^4\,5s$ or $4d^3\,5s^2$ and $4d^4\,5p$ or $4d^3\,5s5p$ electron configurations. Zeeman patterns measured for 911 Cb I lines have been 90 percent interpreted in this analysis, which now includes 86 percent of the known lines and over 93 percent of their intensity. Two members of the series $(4d^4\,ns)\ ^6D$ and two each of $(4d^3\,5s\,np)\ ^4(DFG)$ have been established. Extrapolation of these indicates a limit of 54,600 cm^{-1}, which represents the energy difference between the normal states of Cb atoms and Cb^+ ions. The corresponding ionization potential for neutral columbium atoms is 6.77 volts.

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I. INTRODUCTION

Structural analyses of columbium spectra began 20 years ago, when one of the present authors [1] [1] succeeded in finding three multiplets in the arc spectrum of columbium (Cb I). Two years later the first regularities in the spark spectrum of columbium (Cb II) were announced [2]. The impossibility of extending such analyses without improved and additional descriptive material was recognized, and steps were taken to obtain the desired data. At that time the precision of the published wavelengths was not sufficient to permit finding true "constant differences" in such complex spectra nor were the intensity estimates of arc and spark lines reliable enough for discrimination of ionization stages. The furnace spectra of columbium vapor at various temperatures had not been investigated, and although the published Zeeman-effect data gave the clue to the first regularities in these spectra, they were inadequate for the extension of these analyses.

In 1931 the furnace spectra of columbium were investigated by King [3]. In 1936, new descriptions of arc and spark spectra were published by Meggers and King [4]. These new data formed the basis for a report on multiplets and terms in the first two spectra of columbium published by Meggers and Scribner [5] in 1935. In that report about 400 Cb I lines were accounted for as combinations of sextet and quartet terms, and about 250 Cb II lines as combinations of quintet and triplet terms. Theoretically predicted doublet terms for Cb I and singlet terms for Cb II could not be established at that time. That work indicated that the term analyses of columbium spectra could not be concluded satisfactorily without more extensive and accurate observations of the Zeeman effect. Several years later the unique facilities of the Massachusetts Institute of Technology [6] for making such observations with high magnetic and spectrographic resolution became available, and several sets of Zeeman spectrograms of columbium were made for the Bureau by G. R. Harrison. These were measured, calculated, and interpreted during 1940–41, and the results served to correct and greatly amplify the term analyses of the first two spectra of columbium. Incidental to these analyses, additional observations were made at this Bureau on the arc spectrum in the red and infrared, on the spark spectrum in the ultraviolet, and on the Zeeman effect in the visible and near infrared. The present results for columbium spectra are comparable or superior to those published [7] for the corresponding spectra of analogous vanadium, and since there is now neither opportunity nor necessity for making further observations, this final report on the term analyses of the first two spectra of columbium has been prepared.

Although columbium was discovered 143 years ago, it is only during the past decade that this chemical element has lost its status as a

[1] Figures in brackets indicate the literature references at the end of this paper.

scientific curiosity and found important industrial application. Considerable quantities of columbium are now being used as a constituent of steel [8] and other alloys [9], and since the efficiency and popularity of spectrochemical analysis of such alloys is rapidly increasing, it may be assumed that this report on the structures of columbium spectra will be of interest to practical spectroscopists, as well as to theoretical physicists.

II. OBSERVATIONAL DATA

The analyses of columbium spectra are based on observed facts, consisting of wavelength measurements, intensity estimates and other line characteristics, temperature classification, and Zeeman-effect data, all of which are collected in tables 1 and 4. The second spectrum (Cb II), associated with four valence electrons, is presented first because it is simpler than the first spectrum (Cb I) associated with five electrons, and because the low energy states of Cb II are convergence limits of Cb I spectral series.

1. WAVELENGTHS

Most of the wavelengths shown in tables 1 and 4 are quoted from the description of arc and spark spectra of columbium published by Meggers and King [4]. Their claim that the majority of these values had an average probable error of less than 0.005 A was tested and confirmed by partial analyses [5] based mainly on the combination principle, and has been further verified by the present more complete analyses of these spectra. Supplementary measurements of wavelengths were made in the ultraviolet to extend the data for Cb II lines from 2100 to 2000 A, and new observations were undertaken between 6500 and 8500 A to detect faint lines of Cb I masked by molecular spectra (presumably due to CbO) when the arc-in-air is employed. For the latter purpose an inclosed arc was used, through which pure helium gas was drawn to remove the ambient oxygen. Although this device did not completely eliminate the molecular spectra, it reduced their intensity sufficiently to reveal a considerable number of previously undetected atomic lines. The latter observations were limited to the red and near infrared, because this is the range in which the background of masking molecular spectra is most intense and is also the region in which combinations of series-forming terms are to be expected. The finding of the expected series-forming terms led to a determination of the spectroscopic ionization potential for columbium atoms (see below).

2. INTENSITIES AND OTHER LINE CHARACTERISTICS

Intensity comparisons of columbium lines from arc and spark sources enabled Meggers and King [4] to make a satisfactory separation of Cb I, Cb II, and Cb III or Cb IV spectra. That assignment of lines to Cb I and Cb II spectra has been confirmed for all lines whose Zeeman patterns have been observed and interpreted. Although not sufficiently precise to test quantum rules, the estimated relative intensities in either spectrum were helpful in grouping lines into multiplets and in intrepreting levels.

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Other characteristics of spectral lines that proved useful in the analyses of these spectra are self-reversals (*r* or *R*), hyperfine complexes (*c* or *cW*) and haziness (*h* or *H*).

The absorption spectrum of columbium vapor has never been observed, and an attempt to find reversals in the underwater spark between columbium electrodes failed to give positive results. The only information of this type for columbium is that of partial self-reversals (*r* or *R*) observed for certain lines in arc or spark sources. That such lines involve the ground state (or low metastable state) of the emitter is true without exception in columbium spectra.

A large number of Cb I and Cb II lines exhibit hyperfine structure (*c* or *cW*) due to nuclear spin, and it was assumed by Meggers and Scribner [5] that most of the wide lines (*cW*) involve low levels arising from electron configurations with a single penetrating *s*-type electron, as first mentioned by Meggers and Burns [10] in connection with other spectra. Some of the Cb levels were first found and interpreted on this assumption, and in every case of this kind, subsequent observation of the Zeeman effect has confirmed the interpretation. A value of $I=9/2$ for the nuclear moment of columbium was found from hyperfine structure by Ballard [11], who from observed intervals derived J values of 5/2 and 7/2 for the upper levels of the transitions producing 5344 A and 6661 A, respectively. This analysis establishes the J values in question to be 7/2 and 9/2, respectively.

3. TEMPERATURE CLASSES

King [3] assigned temperature classes (III, IV, or V) to 646 of the stronger lines of columbium between 3100 and 6900 A, by comparing electric-furnace spectra at temperatures of about 2,500° and 2,900° C with arc and spark spectra. Approximately 200 lines appeared in the furnace spectrum, but many Cb I and all Cb II lines require higher excitation. The present analyses of these spectra are consistent with these results.

4. ZEEMAN EFFECT

To this date the only published observations of the Zeeman patterns for Cb lines are those that Jack [12] made 32 years ago. These comprised about 100 lines between 2656 and 4700 A, the majority being reported as pseudotriplets. Component separations of less than 0.6 Lorentz unit were not resolved and lines with patterns less than this in total width were said to be unaffected by the magnetic field. These observations are credited [1, 2] with having revealed the first regularities in Cb I and Cb II, but unfortunately they were not suitable for extending the analyses.

In 1939 and 1940 several sets of Cb spectrograms were made at the Bureau's request in the Spectroscopy Laboratory of the Massachusetts Institute of Technology, where high-power spectrographs were combined with a magnet producing field intensities up to 100,000 oersteds to observe Zeeman patterns surpassing any hitherto seen [6]. With this combination, separations of 0.1 Lorentz unit are readily resolved, and under favorable conditions the resolving power may attain 0.05 Lorentz unit.

These MIT spectrograms extend from 2200 to 6500 A, and the magnetic field intensities range from 74,000 to 95,000 oersteds. The

FIGURE 1.—*Zeeman patterns for* Cb *at 95,000 oersteds.*

1=parallel components, 2=perpendicular components, 3=spectrum without magnetic field.

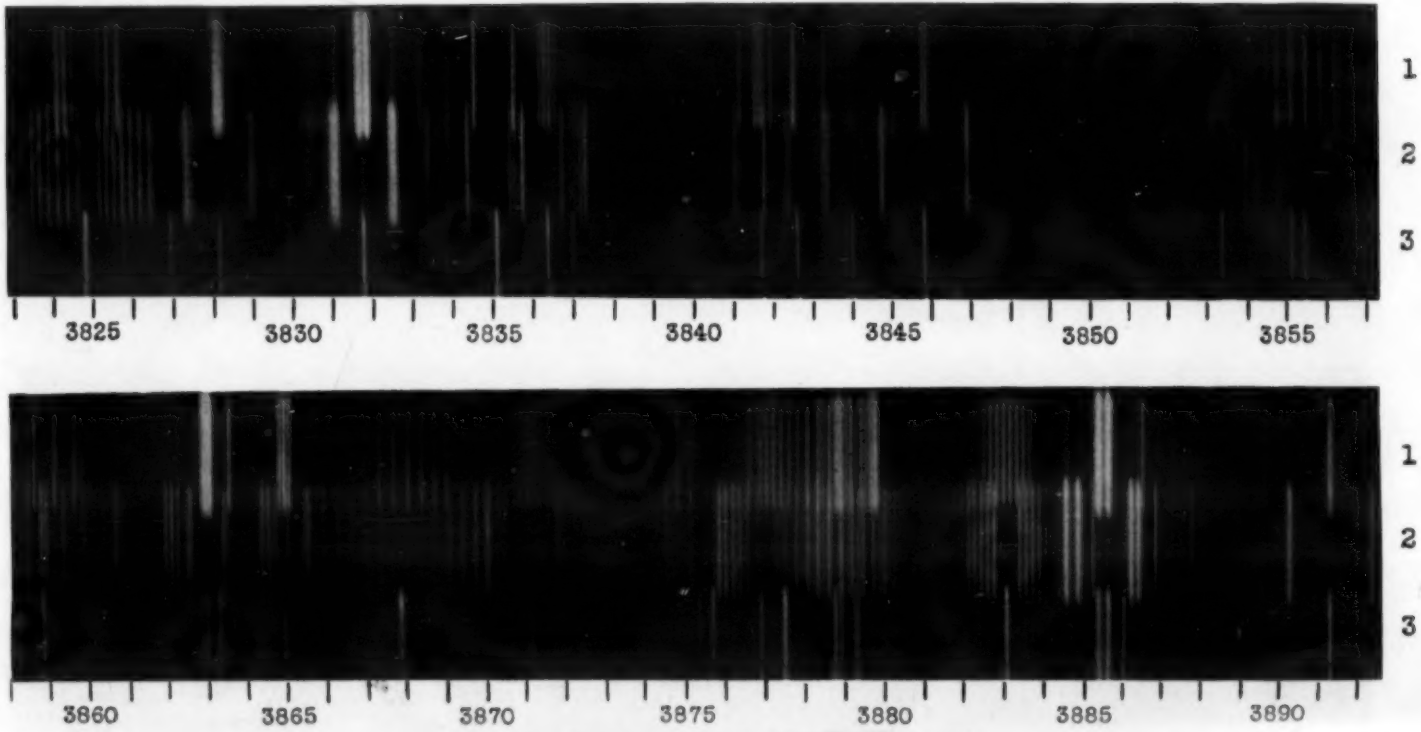

FIGURE 2.—*Zeeman patterns for* Cb *at 95,000 oersteds.*

1=parallel components, 2=perpendicular components, 3=spectrum without magnetic field.

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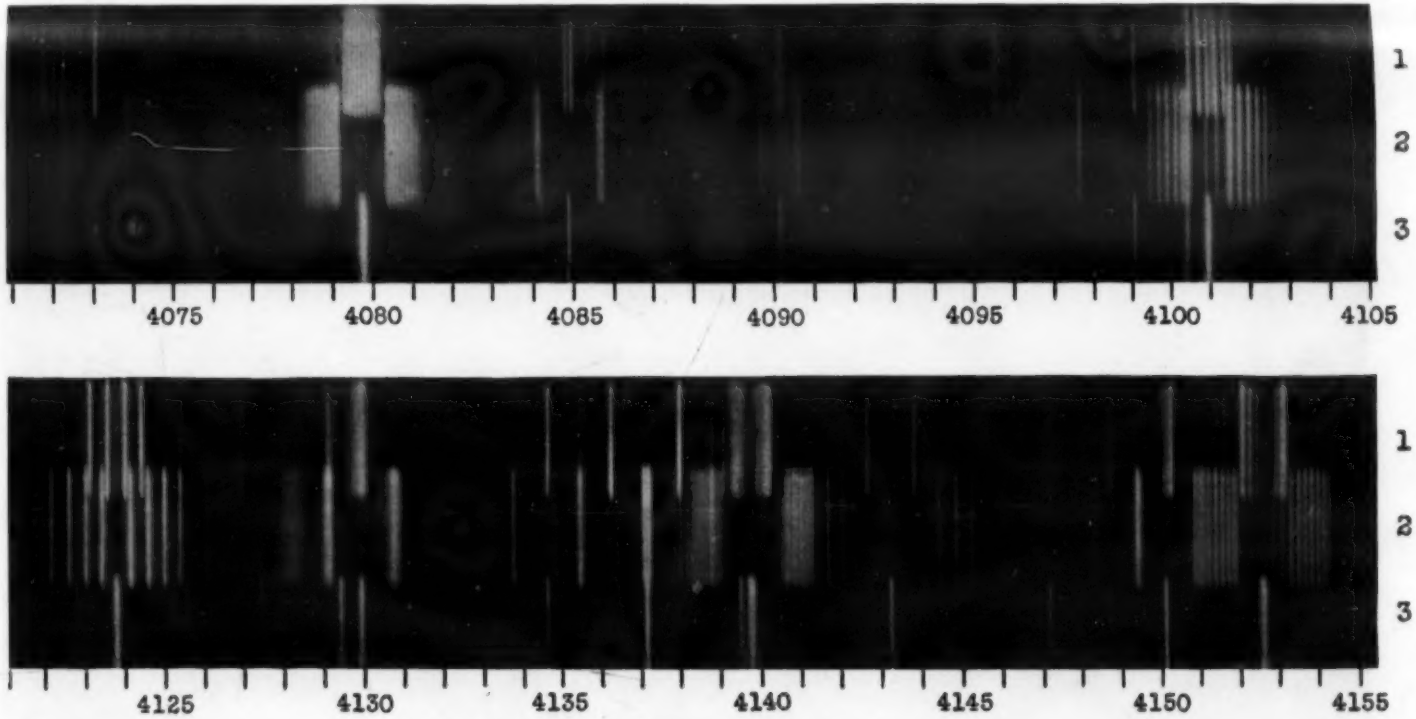

FIGURE 3.—*Zeeman patterns for* Cb *at 95,000 oersteds.*

1=parallel components, 2=perpendicular components, 3=spectrum without magnetic field.

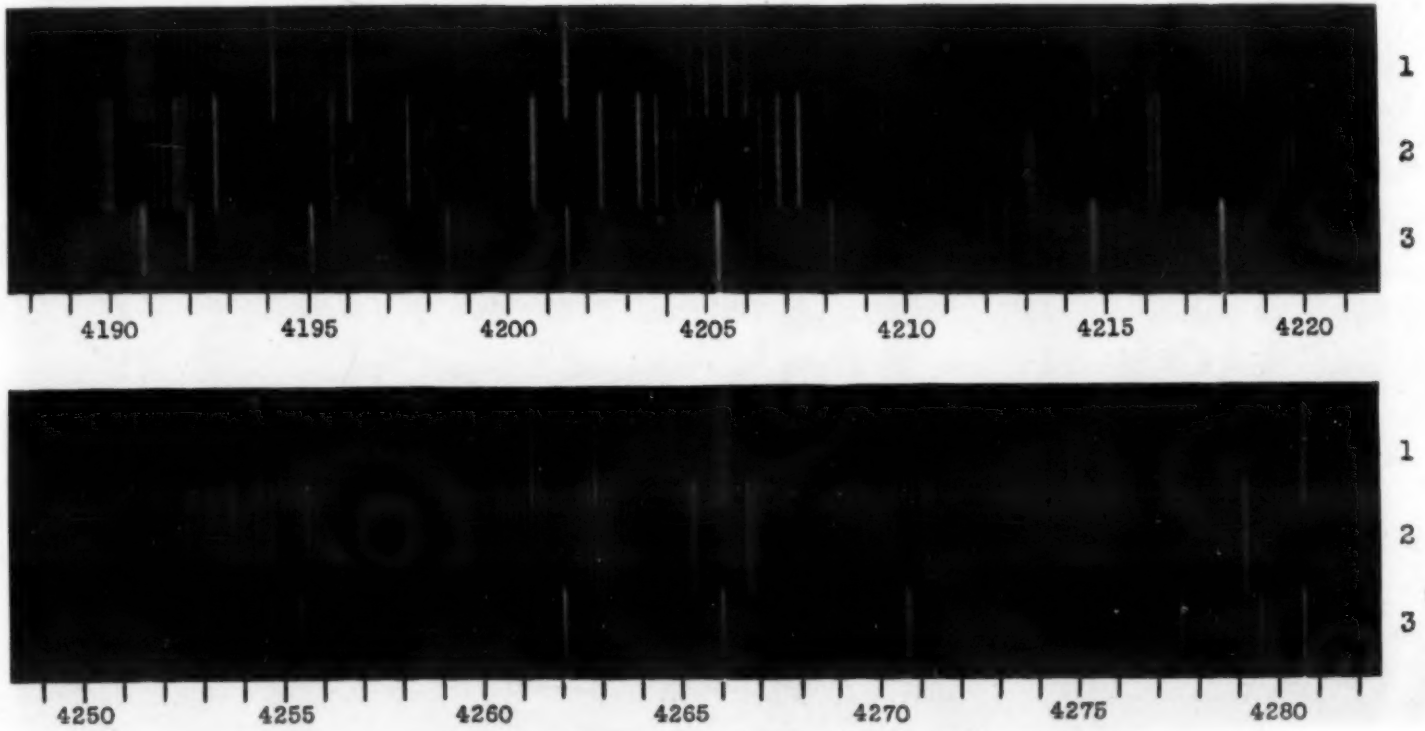

FIGURE 4.—*Zeeman patterns for* Cb *at 35,000 oersteds.*

1=parallel components, 2=perpendicular components, 3=spectrum without magnetic field.

results for wavelengths less than 4500 A, obtained with long focus concave gratings giving a scale of 0.4 A/mm, leave little or nothing to be desired, but most of the longer wave data were derived from spectrograms with a dispersion of 3.7 A/mm. The long wave region 5000 to 8000 A was photographed in the spectroscopy laboratory of this Bureau with a dispersion of 1.8 A/mm, the light source being an interrupted arc between Cb electrodes in an evacuated chamber between the pole pieces of a Weiss electromagnet yielding field intensities of 35,000 oersteds. These observations were extended to 8600 A by employing another grating with a dispersion of 5 A/mm.

All the Zeeman spectrograms were hand measured at the Bureau, and one set of MIT plates was machine measured [13]. Three decimal places were calculated for patterns measured on high-dispersion spectrograms, or when the results from different spectrograms were in good accord. All the measurements were reduced to Lorentz units on the assumption that Cu 3247 A, Ag 3280 A, Ca^+ 3933 A, Na 5889 A, or K 7664 A patterns are represented by (0.333) 1.000, 1.667, and Cu 3273 A, Ag 3382 A, Ca^+ 3968 A, Na 5895, or K 7699 A by (0.667) 1.333. Two or more of these lines appeared on each set of spectrograms.

Although hyperfine structure was obvious in many of the Cb patterns, and fully resolved in some, this phenomenon was ignored in the final compilation of results.

Resolved Zeeman patterns of Cb lines may exhibit from 1 to 30 or more components, but it is impractical and unnecessary to give all in minute detail. The important observed and derived facts concerning the Zeeman effect are presented in the last six columns of tables 1 and 4; the first of which indicates the type of pattern according to the classification of Back and Landé [14], the second reports the separation of resolved components, the third and fourth contain values for the strongest components of parallel and perpendicular polarization, respectively, and the last two exhibit the derived splitting factors of the low and high energy levels responsible for the spectral line. Values in parentheses are borrowed from other lines. All numerical values in the last five columns are expressed in Lorentz units ($L=He/4\pi mc^2$). Some typical Zeeman patterns of columbium lines are displayed in figures 1, 2, 3, 4 as 5× enlarged reproductions from original spectrograms. A few patterns are somewhat unsymmetrical (see 3824.88 A in fig. 2, 4152.58 A in fig. 3, and others marked "*us*" following the Zeeman-type number in tables 1 and 4), but since the splitting factors derived from these were in good accord, no further study was made of these dissymmetries.

FIGURE 4.—*Zeeman patterns for Cb at 35,000 oersteds.*

1=parallel components, 2=perpendicular components, 3=spectrum without magnetic field.

III. TERM ANALYSIS OF Cb II

1. LINES OF THE Cb II SPECTRUM

The available data for 1,723 Cb II lines, characteristic of singly ionized Cb atoms, are displayed in table 1, where column 1 shows the estimated intensity and character, column 2 the measured wavelength, column 3 the vacuum wave number, column 4 the term combinations, and the last six columns contain data on the Zeeman effect. Cb spark lines definitely identified as belonging to Cb III [15] and Cb IV[16] spectra are omitted, and also about 60 lines not observed in the arc

and appearing very hazy (*H*) in the spark. The latter could not be classified as Cb II and some of them may belong to Cb III. The total number of Cb II lines now interpreted as combinations of singlet, triplet, and quintet terms is 1,494. This constitutes 87 percent of the total number listed in table 1, and includes 95 percent of the total intensity. It may be noted that 22 of these lines are doubly classified. In these cases the first term combination is the more probable. The Zeeman patterns observed for 646 Cb II lines constitute the strongest evidence for the correctness of this analysis and interpretation of the Cb II spectrum.

TABLE 1.—*Second spectrum of columbium* (Cb II)

Intensity spark	λ_{air} A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
10h	7026.15	14228.63	$c\,^3F_3-z\,^3D^0_3$	2	0.25	0	0.93	0.68	0.43
30h	6940.90	14403.39	$c\,^3F_3-z\,^3D^0_2$	7b, 1		0	1.04	(1.08)	1.10
4	6929.05	14428.02	$d\,^3P_2-z\,^3P^0_1$						
2	6920.85	14445.11				0	1.32		
20h	6629.11	15080.82	$c\,^3F_4-z\,^3D^0_3$	7b, 1		0	1.09+	(1.24)	1.29
10	6435.53	15534.45	$b\,^3D_3-z\,^3D^0_3$	2	0.74	0	1.93	1.19	0.45
1h	6331.51	15789.66				0	1.31		
5h	6285.81	15904.46	$c\,^3F_4-z\,^3F^0_4$	7b, 1		0	1.20	(1.24)	1.25
2	6249.68	15996.40		3		.14	1.06		
8h	6183.24	16168.29	$c\,^1G_4-z\,^1F^0_3$	7b, 2		0	1.11	(1.09)	1.08
2h	6175.01	16189.84				0	1.14		
2h	6157.83	16235.00				0	1.18		
5h	6119.68	16336.21	$d\,^3P_2-y\,^3D^0_3$	3		.27	1.43±	(1.49)	1.35
5h	6091.80	16410.98	$c\,^3F_3-z\,^3F^0_4$	2	.245	0	2.08	1.10	1.34
5h	6062.17	16491.19	$b\,^1F_3-z\,^1G^0_4$	7b, 2		0	1.24	(1.01)	1.07
15h	6039.95	16551.86	$c\,^3F_4-z\,^3F^0_4$	2		0	1.75−	(1.240)	1.34
2h	6022.41	16600.06				0	1.12		
6h	6000.25	16661.37	$c\,^1G_4-y\,^3F^0_3$	7b, 3		0	1.10	(1.09)	1.11
2h	5979.56	16719.02	$c\,^3F_3-z\,^3F^0_3$						
8h	5973.26	16736.68				0	.98		
6h	5970.67	16743.91	$c\,^3F_4-z\,^3D^0_3$	1	.22	0	.62+	1.28	1.50
4h	5828.85	17151.30		3		.71			
30h	5753.06	17377.24	$b\,^1D_2-z\,^3P^0_2$	3	.33	.66	.98, 1.31	.98	1.31
20h	5746.90	17395.87	$b\,^1F_3-y\,^1G^0_4$	1		0	.86	(1.01)	.97
3h	5690.78	17567.42		3		.97			
2h	5644.66	17710.96	$c\,^1G_4-y\,^3H^0_4$	3		.55		(1.09)	1.95
20h	5635.48	17739.81							
2	5546.35	18024.88	$b\,^3D_2-z\,^3F^0_2$						
100	5545.63	18027.22	$c\,^3F_3-z\,^3G^0_4$	2		0	.91	(.670)	.73
3h	5510.19	18143.17	$b\,^3D_1-z\,^3F^0_2$						
200	5487.60	18217.85	$c\,^3F_3-z\,^3G^0_3$	7b, 1		0	1.06	(1.080)	1.075
30	5455.03	18326.63	$c\,^3F_3-z\,^3F^0_3$	7b, 3		0	.68	(.670)	.690
150	5365.89	18631.07	$c\,^3F_4-z\,^3G^0_4$	7b, 1		0	1.19	(1.240)	1.23
20h	5363.07	18640.86							
25h	5356.84	18662.53	$c\,^3F_3-z\,^3F^0_4$	7b, 3		0	1.09	(1.08)	1.10
10h	5331.19	18752.24	$c\,^3P_1-z\,^1S^0_0$	7a		0	1.21	1.21	0/0
8h	5273.486	18957.53	$b\,^1D_2-y\,^3D^0_3$	3	.24	.48		(.98)	1.22
5c	5237.34	19088.36	$c\,^3F_4-z\,^3F^0_4$						
4h	5165.368	19354.33	$a\,^1P_1-z\,^1S^0_0$	7a		0	1.115	1.115	0/0
4h	5147.94	19419.85	$b\,^1F_3-y\,^1D^0_2$						
2h	5120.492	19523.95	$c\,^1G_4-y\,^1G^0_4$						
2	5006.22	19969.60	$b\,^3G_3-z\,^3D^0_3$						
2	4969.44	20117.37	$c\,^1D_2-y\,^1D^0_2$						
8h	4957.74	20164.87	$b\,^3D_1-z\,^3F^0_2$	2		0	.70	(.68)	.69
3h	4949.44	20198.68	$c\,^3P_2-z\,^1D^0_2$						
4h	4942.00	20229.09	$b\,^3F_3-z\,^5G^0_4$						
15h	4893.885	20427.98	$b\,^3D_2-z\,^3F^0_3$						
2	4891.07	20439.73	$a\,^3D_2-z\,^5G^0_3$						
12c	4865.99	20545.08	$b\,^3F_3-z\,^5G^0_3$	3	.50	.98		.84	(.341)
3h	4854.96	20591.75	$b\,^1D_2-z\,^3P^0_2$						

TABLE 1.—*Second spectrum of columbium* (Cb II)—Continued

Intensity spark	λ air A	Wave No. vac. cm⁻¹	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
3h	4854.74	20592.69	$c\ ^3F_3 - z\ ^1D_2^0$						
4	4852.101	20603.89	$b\ ^3G_4 - z\ ^3D_3^0$						
1	4848.02	20621.23	$c\ ^3P_2 - y\ ^3D_2^0$						
2h	4836.44	20670.61	$c\ ^3P_1 - z\ ^1D_2^0$						
12h	4824.17	20723.18	$c\ ^1D_2 - y\ ^1P_1^0$	1		0	0.89	1.01	(1.13)
2	4822.93	20728.51							
2	4800.07	20827.22	$a\ ^1F_3 - z\ ^3G_4^0$						
4h	4791.48	20864.56	$a\ ^3D_3 - z\ ^3G_3^0$						
100	4789.96	20871.19	$b\ ^3D_3 - z\ ^3F_4^0$	1		0	1.11	(1.312)	1.262
7	4773.80	20941.84	$b\ ^3F_3 - z\ ^3G_4^0$	7b		0	1.15	(1.150)	1.150
3h	4768.23	20966.30	$b\ ^3F_4 - z\ ^3G_4^0$						
3c	4757.22	21014.82	$d\ ^3F_3 - y\ ^3F_3^0$						
2	4735.04	21113.26	$b\ ^3F_3 - z\ ^3G_3^0$						
2c	4717.52	21191.67	$d\ ^3F_3 - y\ ^3P_2^0$						
2c	4700.91	21266.5							
150	4699.58	21272.6	$a\ ^1P_1 - z\ ^1D_2^0$	2	.20	0	1.43	1.11	1.31
100	4670.104	21406.83	$a\ ^3D_2 - z\ ^3D_2^0$	2	.58	0		(1.00)	.42
4h	4669.06	21411.5	$b\ ^3G_3 - z\ ^3F_3^0$						
6h	4665.60	21427.5	$b\ ^3G_4 - z\ ^3F_4^0$						
10h	4660.41	21451.4	$d\ ^3P_1 - z\ ^3D_2^0$	1	.24	0		(1.49)	1.25
6h	4655.30	21474.9	$c\ ^3F_2 - y\ ^3D_2^0$	1	.70	0	.69	.69	1.39
10h	4652.19	21489.3	$c\ ^1D_2 - y\ ^3S_1^0$						
20h	4637.575	21556.98	$c\ ^3P_1 - y\ ^3D_1^0$	7a		0	1.23	1.23	0/0
3	4633.21	21577.3	$a\ ^3D_3 - z\ ^3G_4^0$						
4	4632.85	21579.0	$b\ ^3G_4 - z\ ^3F_4^0$						
4c	4617.655	21649.97	$c\ ^1D_2 - 5273$						
6h	4609.90	21686.4	$d\ ^3P_2 - z\ ^3D_1^0$	7a		0	.83	0/0	.83
2	4608.04	21695.1	$a\ ^1P_1 - y\ ^1D_2^0$						
1h	4598.01	21742.5	$d\ ^3P_1 - 4957$						
50h	4593.79	21762.4	$a\ ^1G_4 - z\ ^3D_3^0$	1	.24	0	.26	1.08	1.32
30h	4589.00	21785.2	$c\ ^3P_2 - y\ ^3D_1^0$	7a		0	1.38	0/0	1.38
2h	4586.73	21795.9	$a\ ^1H_5 - z\ ^3H_4^0$						
6h	4584.10	21808.4	$b\ ^3F_4 - z\ ^3G_3^0$						
5h	4580.50	21825.6	$b\ ^3G_3 - z\ ^3F_3^0$						
150h	4579.446	21830.60	$b\ ^3F_3 - z\ ^3D_2^0$	2		0	1.16	(1.150)	1.145
3h	4566.26	21893.6	$d\ ^3P_1 - z\ ^3D_1^0$						
3h	4556.68	21939.7	$b\ ^1F_3 - w\ ^3G_3^0$						
50h	4550.10	21971.4	$b\ ^3G_3 - z\ ^3F_2^0$						
10h	4548.71	21978.1	$d\ ^3P_1 - w\ ^3D_2^0$						
8c	4535.69	22041.2	$a\ ^3D_3 - z\ ^3D_2^0$	3	.14	.28	1.06±	1.00	1.14
2h	4533.28	22052.9	$a\ ^1F_3 - z\ ^3F_4^0$						
50h	4527.648	22080.35	$b\ ^3F_3 - z\ ^3D_2^0$	2	.43	0	1.28	.85	.42
30h	4522.21	22106.9	$c\ ^3P_2 - y\ ^3D_2^0$	3	.127	.254	1.40±	1.467	(1.340)
6h	4515.93	22137.6	$c\ ^3P_2 - y\ ^3D_1^0$						
8c	4495.46	22238.4	$b\ ^3G_3 - z\ ^3D_1^0$						
200h	4492.962	22250.81	$c\ ^3P_1 - y\ ^3D_2^0$	7b, 2		0	1.23	(1.218)	1.224
2	4489.71	22266.9	$b\ ^3G_4 - z\ ^3D_3^0$	1	.43	0		1.030	(1.460)
2h	4481.01	22310.2	$b\ ^3H_4 - z\ ^3F_3^0$						
7h	4474.66	22341.8	$b\ ^3G_4 - z\ ^3D_2^0$	3	.45	1.80		(1.027)	1.477
20h	4467.92	22375.5	$c\ ^3P_2 - y\ ^3D_1^0$	1		0	1.42	(1.468)	1.452
2h	4461.92	22405.6	$d\ ^3P_2 - z\ ^3D_1^0$						
12c	4460.17	22414.4	$c\ ^3F_4 - y\ ^3D_3^0$						
50h	4449.912	22466.07	$a\ ^3D_3 - z\ ^3D_2^0$	2		0	1.49	1.255	(1.138)
10h	4447.737	22477.05	$d\ ^3P_2 - z\ ^3D_2^0$						
2h	4445.17	22490.0	$d\ ^3P_2 - w\ ^3D_3^0$						
2h	4444.26	22494.6	$a\ ^1H_5 - z\ ^3H_5^0$						
5h	4443.00	22501.0	$c\ ^1F_3 - y\ ^3D_2^0$						
4h	4427.683	22578.86	$c\ ^3P_1 - y\ ^3D_2^0$						
10h	4427.05	22582.1	$d\ ^3P_2 - w\ ^3D_2^0$						
2h	4426.27	22586.1	$a\ ^1G_4 - z\ ^3F_3^0$						
30h	4424.66	22594.3		1		0	.55		
20h	4421.600	22609.61	$c\ ^3P_1 - y\ ^3D_1^0$	3	.24	.24		1.22	(.98)
6h	4413.15	22653.2	$d\ ^3P_1 - z\ ^3P_2^0$						
10h	4408.729	22675.92							
5h	4407.78	22680.8	$d\ ^3P_1 - z\ ^3P_1^0$						

TABLE 1.—*Second spectrum of columbium* (Cb II)—Continued

Intensity spark	λ_{air} Å	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
80h	4401.172	22714.86	$b\ ^3F_3-z\ ^3D_3^0$	3	0.29	0.58	0.85, 1.15	0.85	1.14
7h	4398.55	22728.4							
3h	4396.77	22737.6	$a\ ^1G_4-z\ ^1F_3^0$						
3h	4390.63	22769.4	$c\ ^3F_3-y\ ^3D_3^0$						
3h	4374.60	22852.8	$a\ ^1P_1-y\ ^3D_2^0$						
40h	4372.645	23863.05	$b\ ^3F_2-z\ ^3D_3^0$	3	.159	.476		(1.150)	1.309
100h	4367.966	22887.54	$b\ ^3F_4-z\ ^3D_3^0$	1	.154	0	.690	1.152	1.306
20h	4367.387	22890.58	$b\ ^3D_1-z\ ^1D_2^0$	2	.638	0		(.681)	1.319
3h	4361.34	22922.3							
6h	4348.244	22991.35	$c\ ^3F_3-y\ ^3D_3^0$						
3c	4329.47	23091.0	$b\ ^3H_4-z\ ^3F_3^0$						
80h	4321.49	23133.7	$b\ ^3G_3-z\ ^3G_3^0$	7b, 3		0	.765	(.767)	.763
40h	4317.72	23153.9	$c\ ^1G_4-y\ ^1H_5^0$	1	.089	0		1.089	(1.000)
5h	4312.70	23180.8	$a\ ^1P_1-y\ ^3D_2^0$						
7h	4306.99	23211.6	$a\ ^1P_1-y\ ^3D_1^0$						
8h	4302.91	23233.6	$a\ ^1G_4-z\ ^1F_3^0$						
10h	4300.53	23246.4	$c\ ^3P_1-z\ ^3P_2^0$						
3h	4299.45	23252.3	$a\ ^3D_3-z\ ^3F_3^0$						
2h	4296.44	23268.6	$b\ ^3H_5-z\ ^3F_4^0$						
4	4295.71	23272.5	$b\ ^3F_3-z\ ^3F_3^0$						
2h	4290.35	23301.6	$c\ ^3P_2-y\ ^3D_3^0$						
12h	4274.87	23386.0	$b\ ^3G_4-z\ ^3G_4^0$	3		.15		1.03	(1.07)
5h	4269.92	23413.1	$c\ ^3P_2-z\ ^3P_2^0$						
20h	4267.65	23425.5	$a\ ^1G_4-z\ ^3D_3^0$						
8h	4266.27	23433.1	$b\ ^1G_4-z\ ^1F_3^0$						
4h	4257.19	23483.1	$a\ ^3D_2-z\ ^3F_2^0$						
30c	4254.392	23498.53	$a\ ^3D_1-z\ ^3D_2^0$						
5h	4254.05	23500.4	$a\ ^1G_4-z\ ^3D_4^0$						
15h	4220.596	23686.68	$b\ ^3F_2-z\ ^3F_3^0$	3	.119	.356		(1.150)	1.269
30h	4218.53	23698.3	$b\ ^1F_3-z\ ^1F_3^0$						
50h	4216.228	23711.23	$b\ ^3F_4-z\ ^3F_4^0$	1	.113	0	.800	1.130	1.252
20	4214.81	23719.2	$c\ ^3F_3-z\ ^3F_2^0$	7a		0	1.22	0/0	1.22
2h	4202.880	23786.5	$d\ ^3F_3-y\ ^1F_3^0$						
8h	4199.23	23807.2	$c\ ^3F_3-z\ ^3P_2^0$						
10h	4193.80	23838.0	$b\ ^3F_3-z\ ^3F_4^0$	2	.175	0		(1.150)	1.325
1	4189.47	23862.7	$b\ ^3F_4-z\ ^3F_3^0$						
2	4189.312	23863.57	$c\ ^3P_2-y\ ^3P_1^0$						
80h	4185.54	23885.1	$c\ ^3P_1-z\ ^3P_2^0$	2		0	1.28	(1.218)	1.249
7h	4183.39	23897.3	$a\ ^3D_2-z\ ^3F_3^0$						
2	4181.52	23908.0	$a\ ^3D_3-z\ ^3F_4^0$						
6h	4178.40	23925.9	$b\ ^3F_2-z\ ^3F_2^0$	2		0	1.563	(.849)	.135
5c	4177.873	23928.90	$b\ ^3D_3-y\ ^3D_3^0$						
6h	4172.54	23959.5	$b\ ^1F_3-z\ ^1D_2^0$						
100c	4156.678	24050.91	$b\ ^3G_5-z\ ^3G_4^0$	3		.20	1.21±	(1.19)	1.23
4c	4148.550	24098.03	$b\ ^3D_3-z\ ^3P_2^0$						
4c	4146.980	24107.11	$b\ ^3F_3-z\ ^3D_2^0$						
6h	4140.59	24144.4	$c\ ^3P_2-y\ ^3P_2^0$						
2	4138.91	24154.2	$b\ ^3G_4-z\ ^3G_4^0$						
10h	4138.46	24156.8	$b\ ^3F_2-z\ ^3F_2^0$						
3h	4136.72	24167.0	$c\ ^3P_1-y\ ^3P_0^0$						
20h	4126.180	24228.7	$b\ ^3G_3-z\ ^3F_3^0$						
2h	4122.03	24253.1							
10h	4119.74	24266.6	$b\ ^3D_1-y\ ^3D_2^0$ $c\ ^3F_3-z\ ^3F_3^0$						
100h	4119.284	24269.24	$a\ ^1H_5-z\ ^1H_5^0$	7b, 3		0	1.008	(.902)	1.018
10h	4115.597	24290.96	$c\ ^3P_1-z\ ^3F_2^0$	1	.38	0		(1.468)	1.088
10h	4114.56	24297.1	$b\ ^3D_2-y\ ^3D_1^0$	2	.198	0		(1.171)	.973
8h	4110.81	24319.3	$d\ ^3F_2-w\ ^3D_2^0$						
20h	4110.32	24322.2	$a\ ^3D_1-z\ ^3F_2^0$	3		.07	1.26±	(1.246)	1.269
4h	4109.00	24330.0	$c\ ^3P_1-z\ ^1F_3^0$						
2h	4106.99	24341.9	$b\ ^1G_4-z\ ^1F_3^0$						

TABLE 1.—*Second spectrum of columbium* (Cb II)—Continued

Intensity spark	λ air Å	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	ϕ_1	ϕ_2
1	2	3	4	5	6	7	8	8	10
30h	4104.165	24358.64	$b\ ^3F_4-z\ ^3F_3^1$	2	0.200	0	2.160	1.162	1.362
2h	4101.38	24375.2	$c\ ^1G_4-y\ ^3D_3^1$						
2	4097.93	24395.70	$c\ ^1D_2-x\ ^1F_3^1$						
2h	4096.28	24405.5	$d\ ^3P_2-x\ ^3D_3^1$						
20h	4095.930	24407.62	$c\ ^3P_2-y\ ^3G_3^1$	1	.46	0		(1.408)	1.008
10h	4089.41	24446.5	$c\ ^3F_4-y\ ^3G_3^1$	2	.23	0		(1.240)	1.010
20h	4085.35	24470.8	$b\ ^3D_1-y\ ^3D_2^1$	2	.54	0		(.681)	1.221
5c	4082.65	24487.0	$a\ ^1P_1-z\ ^3P_2^1$						
0h	4079.34	24506.9	$d\ ^3F_4-w\ ^3D_3^1$						
10c	4079.10	24508.3	$b\ ^3G_3^1-z\ ^3F_3^1$						
2	4074.66	24535.0	$b\ ^3D_3-y\ ^3D_3^1$						
1	4074.110	24538.33	$c\ ^3F_2-y\ ^3F_3^1$						
20h	4073.09	24544.5	$a\ ^1G_4-z\ ^3G_3^1$	7b, 3		0	1.075	(1.083)	1.067
15	4072.064	24550.66	$b\ ^3F_4-z\ ^3D_3^1$	1	.305	0	.237	1.152	1.457
5	4068.712	24570.88	$b\ ^3F_3-z\ ^3F_3^1$						
15h	4064.058	24599.02							
10h	4063.734	24600.99	$b\ ^3F_3-z\ ^3D_2^1$	2	.32	0		(1.150)	1.470
60h	4061.98	24611.6	$b\ ^3G_4-z\ ^3F_3^1$	3	.227	0	1.03, 1.26	1.030	1.257
10	4059.68	24625.6	$b\ ^3F_4-z\ ^3D_3^1$						
4h	4054.513	24656.94	$c\ ^1D_2-x\ ^1D_2^1$						
3	4049.90	24685.0	$a\ ^3P_2-z\ ^3D_3^1$ $c\ ^3F_3-z\ ^1F_3^1$						
6h	4048.675	24692.49							
2h	4047.964	24696.82							
4h	4045.58	24711.4	$d\ ^3F_4-5005^1_2$						
1h	4045.06	24714.6	$b\ ^3D_2-z\ ^3P_1^1$						
40h	4037.67	24759.8	$d\ ^3P_1-y\ ^3S_1^1$	3	.329	.328	1.498, 1.828	1.498	1.828
6h	4031.317	24798.81	$b\ ^3D_1-y\ ^3D_2^1$	2	.667	0		(.681)	1.348
8	4030.864	24801.59	$c\ ^3F_3-y\ ^3G_3^1$						
7h	4026.33	24829.5	$b\ ^3D_1-y\ ^3D_1^1$	3	.299	.299		(.681)	.980
4	4023.427	24847.44	$c\ ^3P_1-z\ ^3S_1^1$						
5	4020.233	24867.18	$a\ ^3P_1-z\ ^3D_2^1$						
1	4019.79	24869.9	$a\ ^3G_4-z\ ^3G_3^1$						
4h	4018.995	24874.84	$b\ ^3D_3-z\ ^3P_2^1$						
3h	4016.06	24893.0							
6h	4012.902	24912.60	$b\ ^1D_2-z\ ^3D_2^1$						
30h	4012.165	24917.18	$c\ ^3P_2-y\ ^3F_3^1$	1	.352	0	.413	1.469	1.117
3h	4010.10	24930.0	$a\ ^1S_0-y\ ^3D_1^1$						
5c	4006.995	24949.33	$b\ ^3D_3-y\ ^3D_2^1$						
5	4005.900	24956.15	$c\ ^3F_4-y\ ^3F_3^1$						
80h	4000.605	24989.18	$a\ ^1G_4-z\ ^3F_3^1$	7b, 1		0	1.052	(1.083)	1.093
8	3999.71	24994.8	$b\ ^3F_3-z\ ^3G_3^1$						
2	3999.47	24996.3							
2	3997.335	25009.62	$b\ ^3G_3-z\ ^3F_3^1$						
3h	3994.46	25027.6	$c\ ^3P_0-y\ ^3P_1^1$						
3h	3993.48	25033.8	$c\ ^3P_1-y\ ^3P_1^1$						
2h	3989.17	25060.8	$d\ ^3F_2-x\ ^3P_1^1$						
10h	3983.939	25093.71	$d\ ^3F_3-x\ ^3P_2^1$						
2h	3981.323	25110.20	$a\ ^1F_3-y\ ^1D_2^1$						
200h	3976.52	25140.5	$d\ ^3F_4-x\ ^3G_3^1$						
30h	3971.679	25171.17	$d\ ^3F_3-x\ ^3G_3^1$	2	.10	0	1.00	.71	(.81)
60h	3969.130	25187.34							
3h	3967.95	25194.8	$d\ ^3F_4-x\ ^3F_3^1$						
40h	3967.36	25198.6	$d\ ^3F_3-x\ ^3F_2^1$						
80, V E	3966.276	25205.46	$a\ ^3D_3-z\ ^3G_3^1$	1	.233	0	.297	.996	.763
60h	3964.26	25218.3	$a\ ^1P_1-y\ ^3F_2^1$	1	.370	0		(1.115)	.745
4h	3963.58	25222.6	$a\ ^1H_5-y\ ^3F_4^1$						
8h	3962.163	25231.63	$d\ ^3F_3-x\ ^3G_4^1$						
10h	3961.62	25235.1	$b\ ^3D_3-z\ ^3P_2^1$						
5h	3956.656	25266.74							
20	3955.882	25271.69	$d\ ^3P_2-y\ ^3S_1^1$	1	.328	0	1.157	1.485	1.813

TABLE 1.—*Second spectrum of columbium* (Cb II)—Continued

Intensity spark	λ_{air} A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	θ_1	θ_1
1	2	3	4	5	6	7	8	9	10
3	3955.55	25273.6	$a\ ^3G_3-z\ ^3D^0_2$						
5h	3953.524	25286.76	$b\ ^3D_3-y\ ^3D^0_2$						
100h	3952.367	25294.16	$b\ ^3F_3-z\ ^3F^0_3$	2	0.458	0	2.065	1.149	0.691
1h	3949.70	25311.2	$c\ ^3F_2-y\ ^3F^0_2$						
60h	3949.451	25312.84	$a\ ^1G_4-z\ ^3G^0_4$	2	.154	0	1.86	1.090	1.244
5h	3948.433	25319.36	$c\ ^3P_1-z\ ^3S^0_1$						
4h	3942.905	25354.86	$b\ ^1D_2-z\ ^3D^0_1$						
100h	3938.547	25382.91	$b\ ^1F_3-z\ ^1G^0_4$	75		0	1.007	(1.010)	1.009
150c	3936.02	25399.2	$b\ ^3H_4-z\ ^3H^0_4$	3		.24	.84±	(.88)	.82
30h	3931.70	25426.5	$b\ ^1D_2-z\ ^3D^0_2$ $a\ ^1H_5-y\ ^3G^0_4$						
2	3931.590	25427.83	$c\ ^3F_3-y\ ^3F^0_3$						
10h	3930.022	25437.97	$c\ ^3F_2-z\ ^3F^0_2$						
2	3925.622	25466.48	$b\ ^3D_1-z\ ^3F^0_2$						
2h	3924.02	25476.9	$c\ ^3F_4-z\ ^3F^0_4$						
10h	3921.34	25494.3	$d\ ^3F_4-z\ ^3G^0_4$						
30h	3920.754	25498.10	$d\ ^3F_3-z\ ^3G^0_3$						
100	3919.718	25504.84	$a\ ^3D_3-z\ ^3F^0_3$	3	.309	.620	.691, 1.000	1.000	.691
1h	3915.64	25531.4	$b\ ^1D_2-w\ ^3D^0_2$						
2h	3911.036	25561.45							
6h	3909.331	25572.61	$b\ ^3D_2-z\ ^3P^0_1$						
4	3909.739	25576.48	$b\ ^3H_4-z\ ^3H^0_4$						
5	3900.547	25630.19	$a\ ^3D_1-z\ ^3G^0_3$						
200	3898.292	25645.02	$b\ ^3F_3-z\ ^3G^0_4$	1	.076	0	.843	1.147	1.071
5h	3894.564	25669.57	$b\ ^3F_4-z\ ^3G^0_5$						
15c	3887.32	25717.4	$a\ ^3P_1-z\ ^3D^0_2$						
200c	3879.350	25770.24	$a\ ^1G_4-z\ ^3F^0_4$						
4	3870.936	25826.25	$c\ ^1G_4-z\ ^1F^0_3$						
6h	3870.60	25828.5	$d\ ^3F_3-y\ ^1D^0_2$						
100h	3865.019	25865.79	$a\ ^3D_1-z\ ^3F^0_2$	2	.18	0	.87	.81	.69
150, *E*	3863.056	25878.93	$b\ ^3F_2-z\ ^3G^0_3$	1		0	.615	(.849)	.771
4	3856.704	25921.55	$a\ ^1P_1-z\ ^3S^0_1$						
50h	3855.500	25929.65	$a\ ^3D_3-z\ ^3F^0_3$	2	.560	0	2.366	1.246	.685
4h	3855.07	25932.5	$b\ ^3D_3-y\ ^3G^0_4$						
6h	3852.63	25949.0	$a\ ^3G_4-z\ ^3D^0_3$	1	.26	0		(1.032)	1.312
3h	3850.056	25966.31	$b\ ^3D_1-y\ ^3F^0_2$						
8h	3843.397	26011.30	$c\ ^3P_0-z\ ^3S^0_1$						
10	3841.666	26022.92	$b\ ^3D_2-y\ ^3P^0_1$	1	.387	0	.588	1.175	1.702
1h	3840.16	26033.2	$c\ ^3P_1-z\ ^3S^0_1$						
200, V *E*	3831.840	26089.75	$b\ ^3F_3-z\ ^3F^0_3$	3		.17	1.12±	(1.150)	1.093
20c	3830.601	26098.19	$b\ ^3H_4-z\ ^3H^0_4$	2	.15	0		(.880)	1.03
6h	3829.221	26107.89	$a\ ^1P_1-y\ ^3P^0_1$						
40	3828.242	26114.27	$b\ ^3F_4-z\ ^3F^0_4$	2		0	1.33	(1.182)	1.093
5h	3824.17	26142.1	$b\ ^1D_2-z\ ^3P^0_1$						
4h	3824.00	26143.2	$b\ ^3H_5-z\ ^3H^0_5$						
2	3821.72	26158.8	$b\ ^3G_3-z\ ^1D^0_2$						
200, V *E*	3818.862	26178.40	$b\ ^3F_2-z\ ^3F^0_3$	3	.156	.312	.692, .847	.848	.692
5h	3811.41	26229.6	$b\ ^3D_3-y\ ^3G^0_4$						
2h	3809.27	26244.3	$c\ ^3P_2-w\ ^3F^0_3$						
4h	3808.10	26252.4	$b\ ^1D_2-z\ ^3G^0_3$						
1	3805.23	26272.2	$a\ ^1H_5-y\ ^3H^0_4$						
100, V *E*	3804.733	26275.62	$b\ ^3H_5-z\ ^3H^0_5$	3		.078	1.035±	(1.052)	1.036
10	3804.01	26280.6	$a\ ^3D_3-z\ ^3G^0_4$	1	.173	0	.544	1.226	1.063
80	3801.146	26300.42	$a\ ^3D_2-z\ ^3F^0_2$	2	.093	0	1.27	.991	1.084
6h	3795.527	26339.35							
30h	3792.79	26358.4							
5	3784.88	26413.4	$a\ ^3F_2-z\ ^3G^0_3$	2	.195	0		(.712)	.907
200	3781.379	26437.90	$b\ ^3F_4-z\ ^3G^0_4$	2		0	1.54	(1.152)	1.23
20h	3779.57	26450.6	$b\ ^3D_3-z\ ^3F^0_4$	1		0	.92	(1.171)	1.097
2	3778.50	26458.0	$a\ ^3P_1-z\ ^3D^0_1$						
30h, *E*	3770.66	26513.0	$d\ ^3F_3-e\ ^3F^0_3$						
5h	3764.641	26555.44	$b\ ^3D_1-y\ ^3P^0_1$						
8h	3763.13	26566.1	$c\ ^3P_1-w\ ^3F^0_2$						
2h	3762.99	26567.1	$b\ ^3D_2-y\ ^3G^0_3$						
2h	3762.064	26573.63	$d\ ^3F_3-e\ ^3F^0_4$						
2h	3761.32	26578.9	$d\ ^3F_4-e\ ^3F^0_4$						

TABLE 1.—*Second spectrum of columbium* (Cb II)—Continued

Intensity spark	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	ϕ_1	ϕ_2
1	2	3	4	5	6	7	8	9	10
15h	3760.76	26582.8	$d\ ^3F_3 - y\ ^3F_3^\circ$						
1h	3757.60	26605.2	$c\ ^3F_4 - w\ ^3F_3^\circ$						
3h	3757.466	26606.14	$b\ ^3D_3 - y\ ^3F_4^\circ$						
1	3752.93	26638.3	$c\ ^3F_3 - w\ ^3F_2^\circ$						
1	3752.08	26644.3	$a\ ^3P_2 - z\ ^3D_1^\circ$						
1c	3752.02	26644.8	$a\ ^3P_1 - z\ ^3D_2^\circ$						
20	3751.285	26649.96	$b\ ^1G_4 - z\ ^1H_5^\circ$	3	0.137	0.548		(0.950)	0.814
3	3748.00	26673.3	$a\ ^3D_1 - z\ ^3S_1^\circ$						
10	3741.292	26721.16	$a\ ^1D_2 - z\ ^3F_2^\circ$						
200, V *E*	3740.726	26725.21	$a\ ^3D_2 - z\ ^3F_3^\circ$	3	.162	.478	1.093, 1.252	1.252	1.092
3h	3736.49	26755.5							
3h	3728.03	26816.2	$b\ ^3G_4 - z\ ^3H_4^\circ$						
12c	3726.58	26826.7	$a\ ^3P_1 - z\ ^3D_1^\circ$						
6	3725.25	26836.2	$b\ ^1D_2 - y\ ^1F_3^\circ$						
30h	3723.44	26849.3	$b\ ^1D_2 - y\ ^1D_2^\circ$	7b, 3		0	.974	(.980)	.968
40h	3722.548	26855.71	$b\ ^3D_3 - y\ ^3P_2^\circ$	1	.195	0	.916	1.306	1.501
100	3720.456	26870.81	$b\ ^3F_3 - z\ ^3F_4^\circ$	2	.107	0	1.582	1.154	1.261
20c	3719.63	26876.8	$a\ ^3P_2 - z\ ^3D_2^\circ$						
300, V *E*	3717.06	26895.4	$b\ ^3F_4 - z\ ^3F_4^\circ$	3	.104	.417	1.150, 1.258	1.154	1.258
50h, *E*	3713.72	26919.6	$b\ ^3G_4 - z\ ^3H_5^\circ$						
25h	3713.356	26922.19	$d\ ^3F_4 - y\ ^3F_4^\circ$						
100c, *E*	3709.29	26951.7	$a\ ^3P_1 - z\ ^3D_1^\circ$						
60c	3707.96	26961.4	$a\ ^3P_2 - z\ ^3D_3^\circ$						
3	3701.713	27006.86	$b\ ^3D_3 - z\ ^3S_1^\circ$						
3	3701.44	27008.9	$c\ ^3P_2 - z\ ^1P_1^\circ$						
2	3698.79	27028.2	$c\ ^3F_4 - y\ ^3H_4^\circ$						
10h	3696.68	27043.6	$a\ ^3H_4 - z\ ^3D_3^\circ$						
100	3695.90	27049.3	$b\ ^3P_2 - z\ ^1D_2^\circ$	3	.166	.333	1.312, 1.477	1.478	1.312
10	3694.792	27057.45	$a\ ^1H_5 - z\ ^3I_6^\circ$						
5	3692.178	27076.60	$b\ ^3D_2 - y\ ^3F_2^\circ$						
30	3691.174	27083.97	$b\ ^3P_1 - z\ ^1D_2^\circ$	1	.196	0	1.110	1.502	1.306
3	3689.27	27097.9	$c\ ^3F_3 - w\ ^3F_3^\circ$						
50h	3688.187	27105.90	$a\ ^5G_3 - z\ ^5F_3^\circ$						
200c, V *E*	3687.968	27107.51	$b\ ^3H_5 - z\ ^3H_6^\circ$	7b, 3			1.156±	(1.154)	1.158
4	3684.931	27129.86	$a\ ^3G^3 - z\ ^3F_3^\circ$						
10c	3683.02	27143.9	$a\ ^3P_1 - z\ ^3D_2^\circ$	1	1.000	0	.465	2.465	1.465
6	3681.690	27153.74	$a\ ^3F_4 - z\ ^3G_5^\circ$	2		0	1.350	(1.230)	1.254
2	3681.57	27154.6	$c\ ^3F_4 - w\ ^3F_4^\circ$						
10h	3679.61	27169.1	$b\ ^3H_4 - y\ ^3D_3^\circ$	1	.15	0		(.880)	1.030
40	3678.063	27180.51	$a\ ^1H_5 - z\ ^1G_4^\circ$	1	.08	0	.66	.98	1.06
15	3676.335	27193.29	$b\ ^3D_3 - y\ ^3P_2^\circ$						
20h	3670.05	27239.8	$b\ ^3H_5 - z\ ^3H_6^\circ$						
2	3664.467	27281.36	$a\ ^3G_3 - z\ ^3F_2^\circ$						
60h	3663.751	27286.69							
4	3662.73	27294.3	$a\ ^1F_3 - z\ ^1F_3^\circ$						
300, V *E*	3659.602	27317.62	$b\ ^3G_3 - z\ ^3H_4^\circ$	2		0	.935	(.767)	.809
4	3654.270	27357.48	$d\ ^3F_4 - 5271_4^\circ$						
8h	3652.25	27372.6	$a\ ^5G_4 - z\ ^5D_4^\circ$						
200, V *E*	3651.182	27380.62	$a\ ^3F_3 - z\ ^3D_2^\circ$	2	.296	0	1.010	.714	.418
3h	3648.760	27398.8							
6h	3645.94	27420.0	$a\ ^3G_4 - z\ ^3F_4^\circ$	1	.315	0		(1.052)	1.367
20	3641.382	27454.30	$b\ ^3P_1 - y\ ^3D_1^\circ$	7a		0	1.386	o/o	1.386
15	3641.293	27454.98	$b\ ^1D_2 - y\ ^1P_1^\circ$	1	.144	0	.839	.983	1.127
30	3639.058	27471.84	$b\ ^3P_2 - y\ ^3D_2^\circ$	2	.09	0	1.552	1.482	1.392
15h, E	3637.86	27480.9	$c\ ^3P_1 - z\ ^1P_1^\circ$						
40	3634.489	27506.37	$a\ ^3D_3 - z\ ^3F_4^\circ$ $b\ ^3P_1 - y\ ^3D_2^\circ$						
1h	3634.03	27509.8	$c\ ^3F_3 - w\ ^3F_4^\circ$						
5h	3633.894	27510.88	$c\ ^1G_4 - z\ ^1G_4^\circ$						
100	3633.318	27515.24	$b\ ^3G_3 - z\ ^3H_3^\circ$	3	.144	.720		(1.190)	1.046
4	3633.12	27516.7	$a\ ^1D_2 - z\ ^3F_3^\circ$						

TABLE 1.—*Second spectrum of columbium* (Cb II)—Continued

Intensity spark	λ_{air} A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
30	3629.47	27544.4	$a\ ^1H_5-z\ ^3I_6^0$	2		0	1.280	(0.992)	1.040
2	3628.70	27550.2	$a\ ^3G_3-z\ ^3D_2^0$						
40	3628.180	27554.20	$a\ ^1H_4-w\ ^3F_3^0$	1	0.100	0	.584	.984	1.084
3h	3622.90	27594.4	$b\ ^1D_2-y\ ^3F_2^0$						
2h	3622.40	27597.5	$b\ ^1D_2-z\ ^3F_3^0$						
6h	3620.87	27612.1	$a\ ^3G_4-z\ ^3D_3^0$						
100c, V *E*	3619.729	27618.53	$b\ ^3G_5^0-z\ ^3H_6^0$	2		0	1.06	(1.027)	1.034
200, V *E*	3619.514	27620.17	$a\ ^3F_3-z\ ^3D_2^0$	1		0	.933	(1.070)	1.128
4	3618.89	27624.9	$a\ ^3P_2-z\ ^3D_1^0$						
2h	3614.88	27655.6	$b\ ^3D_3-y\ ^3H_4^0$						
4	3613.25	27668.1	$b\ ^1G_4-y\ ^3D_3^0$						
3	3611.39	27682.3	$d\ ^3F_3-y\ ^1F_3^0$						
6	3609.362	27697.86	$a\ ^1H_4-y\ ^3H_4^0$	2	.133	0		(.992)	1.125
15	3607.01	27715.9	$a\ ^3H_5-z\ ^3I_6^0$	1	.276	0		(1.050)	1.326
2h	3606.35	27721.0	$b\ ^3D_1-z\ ^3S_1^0$						
8h	3604.66	27734.0	$b\ ^3P_2-z\ ^3D_3^0$						
40	3591.197	27837.95	$a\ ^3H_5-z\ ^3F_4^0$	1	.19	0	.21	1.16	1.36
10h	3588.02	27862.6	$c\ ^3F_2-z\ ^1F_3^0$						
50h	3586.75	27872.5	$b\ ^3F_4-z\ ^1H_5^0$	2	.122	0	1.506	.896	1.018
3h	3584.33	27891.3							
4h	3580.98	27917.4	$b\ ^3H_4-z\ ^1H_5^0$						
2	3578.38	27937.7	$b\ ^1G_4-y\ ^3D_3^0$						
10	3574.202	27970.32	$b\ ^3P_1-y\ ^3D_2^0$						
30	3568.50	28015.0	$a\ ^3F_2-z\ ^3D_2^0$	3	.431	.859	.709, 1.142	.710	1.141
40h	3568.001	28018.93	$a\ ^3H_4-z\ ^3F_4^0$						
40h	3566.10	28033.9							
3h	3565.68	28037.2	$a\ ^1F_3-y\ ^3P_2^0$						
1	3565.23	28040.7	$c\ ^3F_3-y\ ^1G_4^0$						
15h	3564.075	28049.79	$b\ ^3H_5-z\ ^3H_6^0$						
4	3561.88	28067.1	$b\ ^1G_4-y\ ^3D_3^0$						
5	3560.47	28078.2	$a\ ^1G_4-z\ ^3H_5^0$						
6h	3559.803	28082.74	$a\ ^1P_1-z\ ^1P_1^0$						
60	3559.592	28085.12	$a\ ^1H_5-y\ ^1G_4^0$	2		0	1.17	(.992)	.96
6h	3554.14	28128.2	$c\ ^3F_3-z\ ^3D_2^0$						
4	3551.102	28152.26	$b\ ^3H_4-y\ ^3G_5^0$						
4h, V *E*?	3548.08	28176.2	$c\ ^3P_2-z\ ^3D_3^0$						
15h	3544.346	28205.92	$c\ ^3P_1-z\ ^3D_2^0$						
50	3541.247	28230.68	$a\ ^3D_2-z\ ^1D_2^0$						
200, V *E*	3540.961	28232.86	$a\ ^3F_4-z\ ^3D_3^0$	1		0	.95	(1.220)	1.333
6h	3539.11	28247.6	$c\ ^3F_2-z\ ^3D_1^0$						
40, V *E*	3537.625	28259.50	$a\ ^3P_2-z\ ^3D_2^0$	3	.312	.621	1.145, 1.458	1.457	1.145
80	3534.215	28286.77	$c\ ^3F_4-z\ ^3D_3^0$						
20	3534.114	28287.58	$d\ ^3F_2-w\ ^3G_3^0$						
10h	3534.05	28288.1							
20	3528.890	28329.46	$b\ ^3H_5-y\ ^3G_4^0$						
30	3528.474	28332.79	$b\ ^3H_4-z\ ^3F_3^0$	1	.203	0	.206	.875	1.078
5	3528.09	28335.9	$b\ ^3G_3-y\ ^3D_2^0$						
8c	3527.024	28344.44	$d\ ^3F_4-w\ ^3G_4^0$						
50h	3525.986	28352.79	$c\ ^3F_2-w\ ^3D_3^0$	1	.157	0	.986	1.457	1.330
10h	3522.366	28381.90	$b\ ^1D_2-527\frac{1}{2}$						
5h	3521.599	28388.10	$b\ ^3D_2-w\ ^3F_3^0$						
20h	3521.14	28391.8	$c\ ^3F_4-w\ ^3D_3^0$	1		0	1.06	(1.240)	1.30
5h	3519.66	28403.7	$b\ ^3D_2-w\ ^3F_2^0$						
150	3517.670	28419.81	$b\ ^1G_4-y\ ^3D_3^0$	1	.083	0	.70	.949	1.032
200c, V *E*	3515.421	28437.99	$a\ ^3G_4-z\ ^3G_5^0$	7b		0	.765	.765	.765
20c	3514.02	28449.3	$b\ ^3H_4-y\ ^3G_4^0$						
400, V *E*	3510.262	28479.78	$b\ ^3G_3-z\ ^3H_4^0$	7b, 2		0	1.118	(1.19)	1.18
8c	3505.992	28514.47	$a\ ^3H_4-z\ ^3F_4^0$						
15	3501.32	28552.5	$b\ ^1G_4-z\ ^3P_2^0$	1	.023	0	.930	.939	1.562
10h	3500.74	28557.3	$c\ ^3P_2-500\frac{1}{2}$						
30c	3499.93	28563.9	$b\ ^3D_3-z\ ^1G_4^0$	1	.228	0	.401	1.313	1.085
30c	3496.027	28595.75	$c\ ^3F_4-500\frac{1}{2}$	7b		0	1.24	1.240	1.240
20	3491.896	28629.57	$b\ ^3P_2-y\ ^3D_3^0$	3	.25	.50	1.24, 1.49	1.49	1.24
10	3490.418	28641.70	$c\ ^3F_3-z\ ^1D_2^0$						
90, V *E*	3489.093	28652.57	$a\ ^3F_2-z\ ^3D_1^0$	3	.240	.722	1.068, 1.308	1.068	1.308

TABLE 1.—*Second spectrum of columbium* (Cb II)—Continued

Intensity spark	λ_{air} Å	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest s	ϕ_1	ϕ_2
1	2	3	4	5	6	7	8	8	10
80	3488.81	28654.9	$c\ ^3F_3 - w\ ^3D_3$						
10	3484.625	28689.31	$b\ ^3G_4 - y\ ^3D_3$						
80, V *E*	3484.054	28694.01	$a\ ^3P_1 - z\ ^3D_2$	3	1.078	1.078	0.416, 1.495	1.495	0.416
100	3482.953	28703.08	$b\ ^1D_2 - y\ ^1F_3$	2		0	1.15	(.98)	1.04
5h	3482.52	28706.7	$a\ ^3H_4 - z\ ^3D_3$						
30	3480.213	28725.68	$b\ ^3D_3 - w\ ^3F_3$	1	.112	0	.842	1.178	1.066
150, V *E*	3479.867	28731.01	$a\ ^3G_4 - z\ ^3G_4$	3		.110	1.056±	1.042	1.070
100, V *E*	3478.79	28737.4	$a\ ^3G_3 - z\ ^3F_3$	2		0	.90	(.765)	.098
6	3476.28	28758.2	$d\ ^3F_2 - e\ ^3D_1$	2	.17	0		.70	(.53)
25c	3474.68	28771.4	$b\ ^3P_2 - z\ ^3P_1$						
20	3474.004	28777.02	$a\ ^1G_4 - z\ ^1H_5$	1		0	.919	(1.083)	1.050
30	3470.27	28808.0	$a\ ^1P_1 - z\ ^1D_2$	2	.143	0	1.404	1.118	1.261
15c	3468.127	28825.78	$b\ ^3H_5 - y\ ^3F_4$						
4c	3461.84	28880.6							
15	3459.56	28897.2				0	.997		
10	3458.728	28904.11	$b\ ^3F_3 - z\ ^1D_2$						
4h	3457.04	28918.2	$b\ ^3H_4 - y\ ^3D_3$						
80	3454.910	28936.06	$c\ ^3P_2 - z\ ^3P_2$	3	.11	.22	1.36, 1.47	1.47	1.36
60	3454.708	28937.74	$b\ ^3D_3 - w\ ^3F_4$	1	.213	0	.470	1.322	1.109
5c	3453.96	28944.0	$a\ ^3P_1 - z\ ^3F_2$						
40	3452.350	28957.51	$b\ ^3P_2 - y\ ^3D_3$	3*us*	.13	.26	1.34, 1.47	1.47	1.34
2h	3452.19	28958.9	$b\ ^3H_4 - y\ ^3F_4$						
20	3451.640	28963.47	$c\ ^3P_2 - z\ ^3P_1$	2	.270	0	1.746	1.476	1.206
60	3450.766	28970.80	$b\ ^3P_2 - y\ ^3D_2$	7*a*		0	.976	0/0	.976
20	3448.674	28988.47	$b\ ^3P_2 - y\ ^3D_2$	2	.498	0	1.982	1.484	.986
40	3443.221	28992.18	$b\ ^3P_1 - y\ ^3D_2$	1*us*	.17	.18	1.18	1.52	1.35
5	3446.928	29003.06	$b\ ^3H_4 - y\ ^3F_3$						
60	3444.281	29025.44	$c\ ^3F_4 - z\ ^3G_4$	1		0	1.05	(1.240)	1.20
20	3443.737	29029.93	$c\ ^3F_3 - z\ ^3D_2$	1	.134	0	.540	.674	.808
10c	3441.64	29047.6	$a\ ^3F_3 - z\ ^3D_3$	2	.590	0		(.712)	1.302
200, V *E*	3440.589	29056.50	$a\ ^3F_4 - z\ ^3F_3$	1		0	1.14	(1.230)	1.200
60, V *E*	3439.925	29062.10	$a\ ^3F_3 - z\ ^3F_2$	2		0	1.116	(1.070)	1.047
80	3438.41	29074.9	$\{b\ ^3H_4 - y\ ^3G_4$ $\{d\ ^3F_3 - w\ ^3G_4$						
60, *E*	3436.964	29087.14	$b\ ^3G_4 - y\ ^3D_3$	3*us*	.270	.810		(.767)	1.037
20	3436.334	29088.24	$a\ ^3G_3 - z\ ^3G_4$						
2h	3435.899	29096.15	$a\ ^1G_4 - y\ ^1D_2$						
2h	3435.583	29098.83	$a\ ^1P_1 - 495\frac{1}{2}$						
3	3433.952	29112.65	$c\ ^3F_4 - z\ ^3G_5$						
5h	3433.747	29114.39	$c\ ^3F_3 - w\ ^3D_3$						
400, V *E*	3432.705	29123.20	$b\ ^1G_4 - z\ ^1H_5$	2		0	1.25	(.950)	1.01
4h	3431.18	29136.2	$a\ ^1I_6 - z\ ^1H_5$						
2h	3430.912	29138.45	$a\ ^1P_1 - z\ ^1S_0$						
250c, V *E*	3426.562	29175.44	$\{a\ ^3G_4 - z\ ^3F_3$ $\{a\ ^3H_4 - z\ ^3G_5$						
300c, V *E*	3425.432	29185.06	$a\ ^3G_3 - z\ ^3G_4$	3		.19	1.21±	1.19	1.23
5c	3423.643	29200.31							
10	3422.85	29207.1	$b\ ^3H_5 - y\ ^3G_5$						
5	3422.77	29207.8	$a\ ^3F_4 - z\ ^3F_4$						
3	3421.318	29220.15	$b\ ^3G_3 - z\ ^3P_2$						
20c	3421.161	29221.49	$a\ ^3P_1 - z\ ^3F_2$						
80, V *E*	3420.633	29226.00	$a\ ^3F_3 - z\ ^3F_4$	2	.590	0	1.302	.712	.122
2	3417.80	29250.2	$a\ ^1P_1 - z\ ^3D_2$						
5h	3417.17	29255.6	$c\ ^3P_1 - z\ ^3P_2$	7*a*		0	1.20	1.20	0/0
20	3413.209	29289.57	$b\ ^3G_3 - z\ ^1H_5$						
150, V *E*	3412.934	29291.93	$a\ ^3P_2 - z\ ^3D_3$	1	.143	0	1.022	1.451	1.308
10h	3412.480	29295.82	$a\ ^1P_1 - w\ ^3D_2$						
100, V *E*	3409.191	29324.09	$a\ ^3P_2 - z\ ^3D_2$	7*a*		0	.423	0/0	.423
100, V *E*	3408.678	29328.50	$a\ ^3P_1 - z\ ^3D_2$	1	.357	0	.758	1.502	1.145
3h	3408.53	29329.8	$c\ ^3F_3 - z\ ^3P_2$						
10	3407.32	29340.2	$c\ ^3P_2 - z\ ^3D_2$	7*a*		0	.817	0/0	.817
10h	3406.947	29343.41				0	.998		

TABLE 1.—*Second spectrum of columbium* (Cb II)—Continued

Intensity spark	λ_{air} A	Wave No. vac cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
3h	3403.49	29373.2	$b\ ^3G_3-z\ ^3P_2^\circ$						
2h	3402.81	29379.1	$c\ ^3F_4-x\ ^3G_3^\circ$						
20	3402.02	29385.9	$c\ ^3F_3-w\ ^3D_2^\circ$	7a		0	0.613	0/0	0.613
10	3401.231	29392.72	$b\ ^3G_4-z\ ^1H_5^\circ$	7b		0	1.067	(1.027)	1.035
30, V *E*	3399.714	29405.83	$b\ ^3P_2-z\ ^3P_1^\circ$	2	0.244	0	1.732	1.488	1.244
5h	3397.516	29424.85	$a\ ^1H_5-z\ ^1G_4^\circ$						
10h	3397.319	29426.56							
50h	3396.365	29434.82	$c\ ^3F_3-x\ ^3F_2^\circ$						
15	3395.72	29440.4	$b\ ^3P_1-z\ ^3P_1^\circ$	3	.281	.284	1.224, 1.501	1.503	1.222
60	3394.978	29446.85	$a\ ^1D_2-z^1D_2^\circ$	3	.297	.602	1.008, 1.302	1.006	1.305
10	3393.810	29456.98	$a\ ^3F_3-z\ ^3F_2^\circ$	3	.314	.628		(.712)	1.026
4h	3392.475	29468.57	$b\ ^3D_3-y\ ^1G_4^\circ$						
9	3391.894	29476.23	$a\ ^3F_3-z\ ^3F_3^\circ$						
30	3389.939	29499.32	$a\ ^3G_4-z\ ^3G_3^\circ$	2	.180	0	1.960	1.060	1.240
250, V *E*	3386.243	29522.81	$a\ ^3H_5-z\ ^3G_4^\circ$	1		0	.962	(1.050)	1.072
10c	3383.302	29548.47							
40h	3382.44	29556.0	$b\ ^1D_2-z\ ^3D_3^\circ$						
150	3380.934	29569.17	$b\ ^3G_3-y\ ^3G_4^\circ$	2		0	1.40	(1.19)	1.14
60	3379.300	29583.46	$b\ ^1G_4-z\ ^1F_3^\circ$	1	.140	0	.515	.935	1.075
9c	3377.375	29600.32	$b\ ^3P_1-z\ ^3P_2^\circ$						
80	3374.252	29627.72	$a\ ^3F_3-z\ ^1F_3^\circ$	2	.258	0	2.067	1.078	1.328
20h	3374.087	29629.17							
120, V *E*	3372.565	29642.54	$a\ ^3G_3-z\ ^3F_2^\circ$	1		0	.86	(1.18)	1.26
30	3370.609	29659.74	$b\ ^3P_1-z\ ^3P_0^\circ$	7a		0	1.510	1.510	0/0
50	3370.184	29663.74	$d\ ^3F_4-w\ ^3G_4^\circ$						
100, V *E*	3369.155	29672.58	$b\ ^3G_4-y\ ^3G_5^\circ$	3	.10	.40	1.07±	1.02	1.12
100	3365.94	29700.9	$b\ ^3D_1-z\ ^1P_1^\circ$	3	.244	0		(.681)	.925
10	3365.883	29701.38	$a\ ^3P_2-z\ ^1F_3^\circ$						
100, V *E*	3365.594	29703.93	$a\ ^3F_4-z\ ^3F_4^\circ$	2	.126	0	1.864	1.234	1.360
20h	3362.17	29734.2	$c\ ^3F_3-x\ ^3G_4^\circ$	2		0	1.43	(1.083)	1.17
100	3360.904	29745.38	$a\ ^1F_3-z\ ^1G_4^\circ$	2		0	1.293	(1.007)	1.078
2	3357.156	29778.60	$a\ ^1H_5-z\ ^3G_4^\circ$						
3h	3355.92	29789.6	$c\ ^3F_2-z\ ^3P_1^\circ$						
1h	3355.67	29791.8	$b\ ^1D_2-e\ ^3D_3^\circ$						
15, V *E*	3353.500	29810.97	$a\ ^3D_3-y\ ^3D_3^\circ$	3	.222	.444		(1.002)	1.224
5h	3352.828	29817.03	$c\ ^3F_3-z\ ^3P_2^\circ$						
3h	3351.87	29825.5	$a\ ^3H_4-z\ ^3G_4^\circ$						
3h	3350.41	29838.5							
100	3349.351	29847.98	$a\ ^1G_4-y\ ^3D_3^\circ$	2		0	1.18	(1.083)	1.05
15	3348.787	29853.01	$b\ ^3G_5^\circ-z\ ^1F_3^\circ$						
20	3348.28	29857.5	$a\ ^1P_1-z\ ^3P_1^\circ$	7a		0	1.120	1.120	0/0
30	3346.760	29871.09	$a\ ^3F_3-z\ ^1F_3^\circ$	2	.555	0	2.381	.716	1.271
20c	3346.286	29875.32	$b\ ^3H_4-y\ ^3H_4^\circ$						
8h	3344.25	29893.5	$b\ ^3D_3-z\ ^3D_3^\circ$						
80	3343.967	29896.03	$a\ ^3F_4-z\ ^1D_2^\circ$	1	.235	0	.53	1.235	1.47
6	3343.90	29896.6	$a\ ^3F_3-z\ ^3D_2^\circ$						
5	3343.28	29902.2	$b\ ^3F_4-z\ ^3H_4^\circ$						
150, V *E*	3341.612	29917.10	$a\ ^3H_5-z\ ^3G_4^\circ$	1		0	.80	(1.157)	1.23
60d	3340.45	29927.5	$c\ ^3F_2-z\ ^3G_3^\circ$	2		0	1.05	(.670)	.80
4h	3340.18	29929.9							
3	3338.38	29946.1	$a\ ^3I_6-z\ ^1H_5^\circ$						
2h	3337.20	29956.7	$a\ ^3G_4-z\ ^3F_4^\circ$						
5c	3335.669	29970.40	$a\ ^3F_4-z\ ^3D_3^\circ$						
10c	3335.244	29974.22	$a\ ^3F_3-z\ ^3D_3^\circ$	1	.73	0	0	.73	1.46
8	3334.82	29978.0	$b\ ^3P_2-y\ ^3D_3^\circ$						
8c	3334.529	29980.65	$a\ ^1G_4-z\ ^3P_1^\circ$						
20h	3329.16	30029.0							
2h	3327.246	30046.28	$d\ ^3F_2-z\ ^1F_3^\circ$						
7, *E*	3326.54	30052.7	$b\ ^3H_5-y\ ^3H_5^\circ$						
20h	3325.436	30062.63							
4h	3325.21	30064.7	$c\ ^3F_4-y\ ^1D_2^\circ$						
50	3324.661	30069.63	$b\ ^3D_3-z\ ^3D_3^\circ$	3			1.300	(1.312)	1.288
30	3324.555	30070.60	$b\ ^3G_3-y\ ^3G_3^\circ$	2	.358	0	2.201	.769	1.127
30	3323.900	30076.52	$b\ ^1G_4-y\ ^3F_4^\circ$	3	.155	.622		(.950)	1.105
3h	3323.22	30082.7	$b\ ^3D_2-w\ ^3D_2^\circ$						

TABLE 1.—*Second spectrum of columbium* (Cb II)—Continued

Intensity spark	λ air A	Wav No. vac. cm⁻¹	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
80	3320.808	30104.52	$b\ ^3G_3 - y\ ^3F_3^1$	7b, 2		0	0.786	(.767)	0.757
2	3320.56	30106.8	$d\ ^3F_3 - z\ ^1F_3^1$						
1	3320.124	30110.72	$b\ ^3P_2 - z\ ^3P_2^1$						
100, V E	3319.590	30115.58	$a\ ^3P_2 - z\ ^3P_1^1$	1	0.183	0	.895	1.444	1.261
10c, V E	3319.22	30118.9	$a\ ^1F_3 - w\ ^1F_3^1$						
5	3318.29	30127.4	$c\ ^3P_2 - z\ ^3P_1^1$						
1	3317.04	30138.7	$a\ ^3D_3 - y\ ^3D_3^1$						
15	3316.61	30142.6	$c\ ^3P_1 - y\ ^1D_2^1$	1	.242	0	.721	1.206	.964
2	3313.64	30169.6	$a\ ^3D_2 - y\ ^3D_2^1$						
4	3313.41	30171.7	$a\ ^3D_1 - y\ ^3D_2^1$						
2h	3313.08	30174.7	$b\ ^3D_3 - w\ ^3D_3^1$						
20h	3310.67	30196.7	$b\ ^3F_3 - y\ ^3D_3^1$						
5	3309.26	30209.6	$b\ ^1G_4 - y\ ^3F_4^1$						
70	3305.608	30242.95	$b\ ^3G_3 - y\ ^3F_3^1$	2		0	1.45	(1.19)	1.12
40	3304.71	30251.2	$b\ ^3G_3 - z\ ^1F_3^1$	3	.330	.990		(.767)	1.097
80	3303.323	30263.86	$b\ ^3P_1 - z\ ^3P_2^1$	3	.224	.448	1.261, 1.482	1.482	1.261
10	3302.619	30270.32	$a\ ^3H_4 - z\ ^3F_3^1$	1	.267	0		(.825)	1.092
3	3301.96	30276.4	$c\ ^3P_2 - y\ ^1P_1^1$						
60	3301.498	30280.59	$b\ ^1G_4 - y\ ^3G_4^1$	2	.216	0	2.050	.970	1.186
0h	3300.33	30291.3	$a\ ^3F_3 - y\ ^3D_2^1$, $a\ ^3H_5 - z\ ^3G_4^1$						
80, E	3299.57	30298.3	$a\ ^3P_1 - z\ ^3P_2^1$						
15	3297.673	30315.71	$a\ ^3F_3 - z\ ^3D_3^1$						
20	3297.055	30321.40	$a\ ^3F_2 - z\ ^3G_3^1$	2	.899	0	3.043	1.245	.346
20	3295.506	30335.65	$b\ ^3D_3 - z\ ^3D_3^1$	2	.34	0		(1.171)	.83
150	3294.367	30346.14	$b\ ^3G_4 - y\ ^3F_4^1$	3		.32	1.07±	(1.027)	1.11
15r	3292.365	30364.58	$a\ ^3F_4 - z\ ^3G_5^1$	2	.46	0	2.59	1.21	.75
200, V E	3292.020	30367.77	$b\ ^3G_3 - y\ ^3G_3^1$	3	.254	.770	.700, 1.014	.765	1.019
30	3291.055	30376.68	$a\ ^3F_4 - z\ ^3G_4^1$	2	.433	0	2.650	1.351	.918
3	3290.55	30381.3	$b\ ^3D_3 - w\ ^3D_3^1$						
10	3289.551	30390.56	$a\ ^3F_3 - z\ ^3D_2^1$	2	.407	0		(1.070)	1.477
3	3287.75	30407.2	$a\ ^3D_3 - y\ ^3D_3^1$, $b\ ^3D_3 - z\ ^3D_3^1$						
5	3286.81	30415.9	$c\ ^3P_2 - v\ ^3F_3$						
40	3286.340	30420.25	$b\ ^3D_2 - w\ ^3D_3^1$	7b		0	1.167	(1.171)	1.163
30c	3285.70	30426.2	$b\ ^3D_1 - z\ ^3D_2^1$						
400, V E	3283.463	30446.91	$b\ ^3G_3 - y\ ^3G_4^1$	3			1.175	(1.19)	1.16
2h	3281.62	30464.0	$c\ ^3F_4 - v\ ^3F_4^1$						
80h	3279.979	30479.25	$b\ ^3G_4 - y\ ^3F_4^1$						
4	3279.43	30484.4	$b\ ^3F_2 - y\ ^3D_2^1$						
20c, V E	3279.248	30486.04	$a\ ^3F_3 - z\ ^3G_4^1$						
4	3277.77	30499.8	$a\ ^3D_1 - y\ ^3D_2^1$						
3	3277.30	30504.2							
6	3276.43	30512.3	$b\ ^3D_2 - w\ ^3D_2^1$	2	.144	0		(1.171)	1.315
30	3274.796	30527.48							
15	3273.888	30535.95	$a\ ^3P_2 - z\ ^3D_3^1$	7b		0	1.46	1.45	1.47
20	3273.511	30539.47	$a\ ^3P_1 - z\ ^3F_2^1$	3		1.35	1.48	(1.504)	.12
10	3272.350	30550.30	$b\ ^3G_4 - y\ ^3G_5^1$						
100	3272.224	30551.48	$a\ ^1G_4 - z\ ^1H_5^1$	1		0	.73	(1.083)	1.012
2h	3270.93	30563.6	$a\ ^3D_3 - y\ ^3D_3^1$						
20	3269.125	30580.44	$b\ ^3P_1 - y\ ^3P_2^1$	7a		0	1.504	1.504	0/0
30	3267.684	30593.92	$a\ ^3H_4 - z\ ^3G_4^1$	2	.403	0	2.854	.839	1.242
80c	3266.11	30608.7							
300, V E	3263.365	30634.41	$a\ ^1H_5 - z\ ^1I_6$	7b, 2		0	1.030	(.992)	1.00
6	3262.56	30642.0							
60	3261.702	30650.03	$a\ ^1F_3 - y\ ^1G_4^1$	1		0	.79	(1.007)	.95
350c V E	3260.564	30660.73	$b\ ^3H_4 - z\ ^3I_5^1$	2		0	.86	(.880)	.877
2	3256.75	30696.6	$b^3P_2^1 - y^3P_1^1$						
1h	3255.80	30705.6	$b^3H_5 - z^3I_6^1$						
5h	3255.27	30710.6	$a^3F_2 - z^3D_3^1$						
25	3254.888	30714.19	$b^3P_2 - y^3P_1^1$	1	.285	0	1.18	1.485	1.745
200r, V E	3254.070	30721.91	$a\ ^3F_3 - z\ ^1G_4^1$	3	.655	1.306	335, .995	.993	.338
1	3253.16	30730.5	$b\ ^1G_4 - z\ ^3F_3^1$						
10	3252.430	30737.41	$a\ ^1F_3 - z\ ^3D_2^1$	1	.25	0	.50	1.00	1.25
50	3251.260	30748.47	$b\ ^3P_1 - y\ ^3P_1^1$						
40	3250.27	30757.8	$b\ ^3D_3 - z\ ^3P_2^1$	1		0	1.23	(1.312)	1.35
80, V E	3248.941	30770.41	$a\ ^3P_1 - z\ ^3F_2^1$	1	.458	0	.565	1.481	1.023

TABLE 1.—*Second spectrum of columbium* (Cb II)—Continued

Intensity spark	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	ϕ_1	ϕ_2
1	2	3	4	5	6	7	8	9	10
150c, V *E*	3247.478	30784.28	$a\ ^3F_3-z\ ^3G_4^0$						
6	3246.69	30791.7	$b\ ^3G_3-x\ ^3F_3^0$						
5	3245.07	30807.1	$c\ ^3F_4-v\ ^3F_4^0$						
30	3244.515	30812.39	$b\ ^3F_3-y\ ^3D_3^0$	3	0.494	0.996	0.850, 1.338	0.846	1.340
6	3243.53	30818.9	$c\ ^3F_3-v\ ^3F_3^0$						
40	3242.532	30831.23	$a\ ^1G_4-y\ ^3G_4^0$	3		.16	1.10±	1.08	1.12
8	3242.423	30832.27	$a\ ^3D_3-y\ ^3D_3^0$						
40	3241.818	30838.02	$b\ ^3H_4-z\ ^3I_4^0$	3	.188	.94		(1.052)	.864
3	3241.29	30843.0	$b\ ^3F_3-y\ ^3D_3^0$						
2h	3239.23	30862.7	$b\ ^3D_3-z\ ^3F_3^0$						
80c, V *E*	3238.020	30874.19	$a\ ^3P_2-z\ ^1D_2^0$						
60	3237.690	30877.34	$b\ ^3G_3-y\ ^3F_3^0$	3	.36	1.10		(.767)	1.13
300r, V *E*	3236.403	30889.62	$a\ ^3F_2-z\ ^3G_3^0$	3	.328	.984	.921, 1.246	1.248	.920
2h	3235.78	30895.6	$b\ ^3D_3-x\ ^3G_4^0$						
5h	3232.79	30924.1							
40	3230.243	30948.52	$b\ ^3F_3-y\ ^3D_2^0$	3	.107	.34	1.033, 1.138	1.140	1.033
100, V *E*	3229.567	30955.00	$a\ ^3P_2-z\ ^3D_2^0$	7b		0	1.465	1.465	1.465
6	3228.953	30960.88	$b\ ^3H_3-z\ ^1G_4^0$	1		0	.956	(1.052)	1.076
6	3228.47	30965.5							
6	3227.69	30973.0	$b\ ^3F_4-y\ ^3D_3^0$						
500c *R*, V *E*	3225.478	30994.24	$a\ ^1F_3-z\ ^1G_4^0$	2	.36	0	.72	0.000	.36
100, V *E*	3223.332	31014.87	$a\ ^3F_4-z\ ^3G_5^0$	3	.156	.627	1.076, 1.234	1.233	1.077
80	3222.065	31027.07	$a\ ^1D_2-y\ ^3D_2^0$	3	.220	.432	1.002, 1.226	1.004	1.224
8c	3221.555	31031.02	$b\ ^3H_4-y\ ^3H_4^0$						
4h	3220.48	31042.3	$c\ ^3F_3-y\ ^3S_3^0$						
2	3219.53	31051.3	$a\ ^3H_4-z\ ^3F_4^0$						
3h	3218.98	31056.8	$a\ ^3P_1-z\ ^1D_2^0$						
60c	3217.00	31075.9	$b\ ^3H_5-y\ ^3H_5^0$						
2	3216.47	31081.0	$b\ ^3F_2-y\ ^3D_2^0$						
6	3216.193	31083.71	$a\ ^3F_3-z\ ^3F_4^0$	2	.28	0	1.84	1.08	.70
300cr, V *E*	3215.595	31089.49	$a\ ^3F_4-z\ ^3G_4^0$	3	.190	.792	1.145, 1.346	1.349	1.150
5h	3215.00	31095.2	$b\ ^3D_3-x\ ^3F_2^0$						
3	3213.91	31105.8	$a\ ^3P_1-z\ ^3D_2^0$						
10	3212.14	31122.9	$b\ ^3D_3-z\ ^3F_4^0$	7b, 1		0	1.151	(1.171)	1.191
20	3211.814	31126.09	$b\ ^1G_4-y\ ^3H_5^0$	7b, 3		0	.954	(.950)	.958
2h	3211.63	31127.9	$a\ ^1G_4-y\ ^3G_5^0$						
3h	3211.40	31130.1	$c\ ^3F_2-y\ ^1F_3^0$						
4	3210.20	31141.7	$b\ ^3P_1-z\ ^1F_3^0$	1	.283	0	.330	1.479	1.096
40c	3208.585	31157.41	$b\ ^3H_4-w\ ^3F_4^0$	3	.23	.91	.87, 1.10	.87	1.10
3	3208.409	31159.12	$a\ ^3D_3-y\ ^3D_3^0$						
8	3208.10	31162.1	$c\ ^3F_3-v\ ^3F_3^0$						
2	3207.86	31167.4	$a\ ^3D_1-z\ ^3P_2^0$						
20	3207.341	31169.50	$a\ ^3P_0-z\ ^3F_1^0$	7a		0	.135	0/0	.135
300rs, V *E*	3206.350	31179.14	$a\ ^3F_3-z\ ^3G_3^0$	2		0	.87	(.712)	.763
100c	3204.973	31192.53	$b\ ^3H_5-z\ ^3I_5^0$	3	.11	.06	1.10±	1.155	1.045
150	3203.357	31208.26	$b\ ^3H_5-y\ ^3H_5^0$	3		.06	1.04±	1.05	1.03
10h	3203.148	31210.30							
3	3201.66	31224.8							
1	3200.78	31233.4	$b\ ^3D_3-x\ ^3G_4^0$						
1	3200.69	31234.3	$b\ ^3F_3-z\ ^3F_3^0$						
3h	3200.24	31238.7							
4h	3199.88	31242.2	$c\ ^3F_4-527\frac{1}{2}$						
20	3198.227	31258.32	$b\ ^3F_3-y\ ^3G_3^0$	1	.459	0	.101	1.479	1.019
20h	3197.28	31267.6							
3	3196.17	31278.4	$c\ ^3F_3-v\ ^3F_3^0$						
2	3195.96	31280.5	$b\ ^3F_3-y\ ^3D_2^0$						
5	3195.216	31287.77	$a\ ^3P_1-z\ ^3D_1^0$						
700*R*, V *E*	3194.983	31290.06	$a\ ^3F_2-z\ ^3G_3^0$	1	.063	0	.742	.991	.908
30c	3194.27	31297.0	$a\ ^3P_2-y\ ^3D_1^0$	2	.435	0	2.258	1.823	1.388
3	3193.47	31304.9	$b\ ^3F_4-y\ ^3D_4^0$						
2	3192.39	31315.5	$c\ ^3F_4-y\ ^1H_5^0$						
3	3192.16	31317.7	$a\ ^1S_0-z\ ^1P_1^0$						
250, V *E*	3191.427	31325.45	$b\ ^3H_5-z\ ^3I_6^0$	7b, 2		0	1.057	(1.052)	1.062
200c V *E*	3191.096	31328.17	$a\ ^3F_3-z\ ^3G_4^0$	3	.16	.80	1.31±	1.39	1.23
6	3190.44	31334.6	$b\ ^3H_5-w\ ^3F_4^0$						

TABLE 1.—*Second spectrum of columbium* (Cb II)—Continued

Intensity spark	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
10c, V *E*	3189.288	31345.93	$b\ ^3H_5-y\ ^3H_5^0$	3		0.18	1.146±	1.16	1.13
4	3188.85	31350.2	$a\ ^3P_1-y\ ^3P_1^0$	7*b*		0	1.11	1.11	1.11
4	3188.36	31355.0	$a\ ^1D_2-y\ ^3D_2^0$	3	0.333	.666		(1.003)	1.336
2	3185.23	31385.9	$a\ ^1D_2-y\ ^3D_1^0$						
2	3184.94	31388.7	$b\ ^1D_2-z\ ^1D_2^0$						
10	3184.229	31395.72	$b\ ^3G_4-y\ ^3H_5^0$	3		.24	.99±	1.02	.96
40	3181.403	31423.61	$a\ ^3P_2-z\ ^3G_3^0$	1	.69	0	.63	1.44	.75
400, V *E*	3180.290	31434.61	$a\ ^3F_3-z\ ^3G_4^0$	7*b*, 2		0	1.085	(1.070)	1.074
8	3179.242	31444.97	$a\ ^3D_3-z\ ^3P_2^0$	3	.25	.50	1.01, 1.26	1.01	1.26
6	3177.766	31459.58	$a\ ^3F_4-z\ ^3F_3^0$	2	.140	0	1.650	1.230	1.090
2	3177.41	31463.1	$a\ ^3G_3-z\ ^1D_2^0$						
4	3176.14	31475.7	$b\ ^3D_1-z\ ^3P_2^0$						
150, V *E*	3175.86	31478.5	$a\ ^3F_3-z\ ^3F_3^0$ $b\ ^3H_5-y\ ^3H_5^0$						
50, V *E*	3175.76	31479.4	$a\ ^3P_1-y\ ^3D_2^0$	3	1.105	1.10	1.37, 2.48	2.48	1.37
1	3174.73	31489.7	$a\ ^1P_1-y\ ^3F_2^0$						
6h	3174.44	31492.5	$b\ ^3D_3-y\ ^1D_2^0$						
150	3173.205	31504.79	$a\ ^1G_4-y\ ^3F_4^0$	3		.110	1.094±	1.080	1.108
1	3167.96	31557.0	$c\ ^3F_4-w\ ^3P_2^0$						
3h	3167.32	31563.3	$c\ ^3F_4-y\ ^1F_3^0$						
1	3165.24	31584.1	$a\ ^3D_3-y\ ^3D_2^0$						
600*R*, V *E*	3163.403	31602.41	$a\ ^3F_3-z\ ^4G_4^0$	1	.107	0	.834	1.262	1.155
10	3163.149	31604.95	$a\ ^3P_1-z\ ^1D_2^0$	7*b*, 1		0	1.46	1.49	1.48
4	3161.56	31620.8	$d\ ^3P_2-u\ ^3D_1^0$	7*a*		0	.645	0/0	.645
4c	3161.244	31624.00	$a\ ^1D_2-y\ ^3D_3^0$						
15	3159.855	31637.89	$a\ ^1G_4-y\ ^3F_4^0$	1		0	.99	(1.083)	1.113
10	3158.104	31655.43	$b\ ^3D_1-z\ ^3P_1^0$	3	.525	.526	.675, 1.198	.675	1.200
3	3156.00	31676.5	$b\ ^3F_4-z\ ^1H_5^0$						
30	3155.599	31680.56	$b\ ^3P_2-z\ ^3S_1^0$	7*a*		0	1.824	0/0	1.824
100c	3154.820	31688.38	$b\ ^3H_4-y\ ^1G_4^0$	3		.23	.92 ±	.89	.95
10	3153.851	31698.12	$b\ ^3P_2-z\ ^3S_1^0$	1	.34	0	1.13	1.47	1.81
4h	3153.38	31702.9	$d\ ^3P_1-u\ ^3D_2^0$						
70	3152.785	31708.84	$a\ ^1G_4-y\ ^3G_5^0$	2		0	1.51	(1.083)	1.17
200	3152.160	31715.12	$a\ ^1H_5-y\ ^1H_5^0$	3		.15	1.003±	(.992)	1.014
30	3150.409	31732.75	$b\ ^3P_1-z\ ^3S_1^0$	3	.319	.319	1.508, 1.827	1.508	1.827
30	3146.92	31767.9	$b\ ^3P_2-y\ ^3F_3^0$	1	.355	0	.415	1.480	1.125
60*Rv*, V *E*	3145.408	31783.23	$a\ ^3F_4-z\ ^3G_5^0$	7*b*		0	1.23	(1.230)	1.230
60	3144.353	31793.87	$b\ ^3G_3-y\ ^3H_4^0$	2	.194	0	1.554	.778	.972
4	3143.41	31803.4	$a\ ^1D_2-z\ ^3P_1^0$						
3	3143.17	31805.8	$a\ ^3D_1-z\ ^3P_2^0$						
100c	3142.26	31815.0							
4	3140.97	31828.1	$d\ ^3P_1-u\ ^3D_1^0$						
150	3140.506	31832.81	$b\ ^3F_3-y\ ^3D_2^0$	2	.181	0	1.400	.857	1.038
3h	3137.98	31858.4	$b\ ^1G_4-w\ ^3F_3^0$						
3	3137.27	31865.6	$b\ ^3H_5-y\ ^1G_4^0$						
30	3135.920	31879.36	$a\ ^3F_3-z\ ^3F_3^0$	3		.055	1.052	1.073	1.091
25	3135.409	31884.55	$b\ ^3P_2-y\ ^3P_2^0$	3		.045	1.496	1.485	1.507
40	3134.342	31895.41	$a\ ^3D_3-y\ ^3P_2^0$	1	.770	0	.239	1.009	1.779
60	3132.767	31911.44	$b\ ^1G_4-z\ ^1I_6^0$	1		0	.53	(.950)	.87
4	3132.140	31917.83	$a\ ^3P_2-z\ ^5D_1^0$	7*a*		0	1.45	0/0	1.45
10	3132.015	31919.11	$b\ ^3P_1-y\ ^3P_2^0$	7*b*, 2		0	1.52	(1.504)	1.51
1500*R*, V *E*	3130.780	31931.70	$a\ ^5F_4-z\ ^4G_5^0$	1		0	.86	(1.350)	1.25
60	3129.65	31943.2	$a\ ^3P_1-y\ ^5D_0^0$	7*a*		0	2.470	2.470	0/0
10c	3128.92	31950.7	$a\ ^3P_2-y\ ^3D_3^0$						
20	3128.372	31956.27	$b\ ^3F_4-y\ ^3G_5^0$	3		.109	1.13±	1.14	1.12
800, V *E*	3127.526	31964.92	$b\ ^3H_4-z\ ^3I_5^0$	2		0	1.124	(1.154)	1.150
10	3125.892	31981.62							
6c	3119.48	32047.4							
10c	3116.57	32077.3	$a\ ^1F_3-z\ ^3G_4^0$						
20	3115.533	32087.96	$a\ ^3D_1-y\ ^3P_1^0$	7*a*		0	.506	.506	0/0
15	3115.16	32091.8							

TABLE 1.—*Second spectrum of columbium* (Cb II)—Continued

Intensity spark	λ_{air} A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest s	p_1	p_2
1	2	3	4	5	6	7	8	9	10
30	3113.17	32112.3	$b\ ^3F_3 - z\ ^1F_3^0$	3		0.16	1.120	1.146	1.094
5	3111.63	32128.2	$b\ ^3G_4 - w\ ^3F_3^0$						
20	3110.800	32136.78	$b\ ^3F_4 - z\ ^1F_3^0$	2		0	1.29	(1.15)	1.10
80	3106.980	32176.29	$a\ ^3D_2 - y\ ^3F_2^0$	3	0.268	.540	.738, 1.003	1.004	.735
10	3106.520	32181.05	$b\ ^3G_4 - z\ ^3H_4^0$						
2	3104.62	32200.7	$b\ ^3G_3 - z\ ^1G_4^0$						
8	3104.27	32204.4	$b\ ^3G_3 - w\ ^3F_3^0$	2		0	1.01	(.767)	.64
4	3103.26	32214.9	$d\ ^3P_2 - u\ ^3D_3^0$						
20	3101.918	32228.80	$b\ ^3F_3 - y\ ^3G_4^0$	3	.13	.39		(1.150)	1.02
20	3100.79	32240.5	$a\ ^3F_4 - z\ ^3F_3^0$	3		.09	1.246	1.233	1.259
50	3100.25	32246.1							
100, V *E*	3099.180	32257.27	$a\ ^3F_4 - z\ ^3D_3^0$	2	.579	0	1.578	.999	.420
10	3098.47	32264.7	$a\ ^3G_4 - z\ ^3H_4^0$	3	.24	.96		(1.052)	.81
60c	3097.115	32278.76	$a\ ^3P_2 - y\ ^3D_3^0$	2	.314	0	2.290	1.662	1.348
2000c*R*, V *E*	3094.172	32309.47	$a\ ^3F_3 - z\ ^3G_4^0$	1		0	.90	(1.30)	(1.31)
6	3092.89	32322.9	$a\ ^3D_2 - z\ ^1F_3^0$			0	1.23	(1.002)	1.08
3	3089.110	32362.42	$b\ ^3D_1 - y\ ^1D_2^0$	2	.290	0		(.681)	.971
90	3087.860	32375.52	$a\ ^1D_2 - y\ ^3D_3^0$	7b, 2		0	1.053	(1.003)	1.028
20h	3086.09	32394.1	$d\ ^3F_3 - u\ ^3F_3^0$	3	.29	.58		(.70)	.99
2	3084.760	32408.05	$b\ ^1G_4 - w\ ^3F_3^0$						
50	3084.369	32412.16	$b\ ^3P_2 - z\ ^3S_1^0$	3	.465	.936	1.480, 1.943	1.480	1.945
30c	3083.32	32423.2	$d\ ^3P_2 - u\ ^3D_3^0$						
40	3081.77	32439.5	$a\ ^3D_2 - y\ ^3G_3^0$	2		0	1.034	(1.002)	1.013
8	3081.09	32446.7	$b\ ^3P_1 - z\ ^3S_1^0$						
100	3080.345	32454.50	$a\ ^3P_2 - y\ ^3D_2^0$	2	.587	1.176	1.223, 1.808	1.810	1.223
10	3077.44	32485.1	$a\ ^1S_0 - z\ ^3D_1^0$	7a		0	.83	0/0	.83
200	3076.864	32491.21	$a\ ^3F_4 - z\ ^3D_3^0$	1		0	1.478	(1.248)	1.133
1h	3076.23	32497.9	$c\ ^3P_2 - v\ ^3D_3^0$						
10	3075.250	32508.27	$a\ ^1D_2 - z\ ^3P_1^0$	2	.562	0	2.690	1.004	1.566
5	3074.27	32518.6	$a\ ^3P_2 - z\ ^3F_3^0$	1	.360	0	.38	1.44	1.08
50	3073.232	32529.61	$a\ ^3F_4 - z\ ^3D_3^0$	3	.418	.418	0.00, .417	0.000	.418
60	3072.502	32537.34	$a\ ^3D_1 - y\ ^3F_2^0$	2	.23	0	.96	.50	.73
10	3072.18	32540.7							
90c	3071.65	32547.4	$a\ ^3P_2 - y\ ^3D_2^0$						
40	3071.18	32551.3	$b\ ^3G_4 - y\ ^3H_4^0$						
80	3070.993	32554.39	$a\ ^1G_4 - y\ ^3H_4^0$						
100	3069.68	32567.2	$a\ ^3D_3 - y\ ^3G_4^0$	1	.132	0	.730	1.258	1.126
5	3069.51	32569.0	$b\ ^3F_3 - y\ ^3F_3^0$						
5	3068.93	32575.2	$b\ ^3D_3 - x\ ^3F_3^0$						
20	3068.06	32584.4	$b\ ^3D_3 - v\ ^3F_3^0$			0	.97	(1.171)	1.10
20	3067.523	32590.15	$b\ ^3D_3 - v\ ^3F_4^0$	1		0	1.14	(1.312)	1.28
4	3066.49	32601.1	$a\ ^3D_3 - y\ ^3F_3^0$						
60	3066.09	32605.4	$b\ ^3F_3 - y\ ^3F_4^0$	1		0	1.04	(1.150)	1.12
100c	3065.26	32614.2	$a\ ^3P_2 - z\ ^3P_1^0$	1	.44	0	1.38	1.82	2.26
250r	3064.530	32621.98	$a\ ^3G_3 - z\ ^3H_4^0$	2		0	.87	(.765)	.80
120	3063.782	32629.94	$b\ ^3F_4 - y\ ^3F_4^0$	3		.19	1.07±	1.05	1.10
40	3063.126	32636.93	$a\ ^3P_1 - y\ ^3D_2^0$	1	1.238	0	0	2.476	1.238
10	3061.95	32649.5	$a\ ^3G_3 - z\ ^3H_3^0$	3	.136	.744		(1.180)	1.044
5	3061.408	32655.25							
4	3060.844	32661.26	$c\ ^3P_2 - z\ ^3D_2^0$ $a\ ^1D_2 - z\ ^3P_2^0$						
20	3059.294	32677.81	$b\ ^3G_4 - w\ ^3F_4^0$	3		.26	1.06±	1.03	1.09
3	3058.62	32685.0							
12	3057.03	32702.0	$b\ ^3G_3 - z\ ^1G_4^0$	2	.325	0		(.767)	1.092
200	3055.520	32718.17	$b\ ^3G_3 - y\ ^3H_4^0$	1		0	90	(1.19)	1.14
90	3053.631	32738.41	$b\ ^3F_3 - y\ ^3F_3^0$	3		.08	1.138	1.152	1.124
15	3051.34	32763.0	$b\ ^3F_4 - y\ ^3F_4^0$			0	1.22	(1.157)	1.13
40c	3049.528	32782.45	$a\ ^3P_2 - y\ ^3D_3^0$	3	.47	.93	1.37, 1.84	1.83	1.26
5	3048.63	32792.1	$a\ ^3P_1 - z\ ^3F_2^0$						
80c	3048.21	32796.6	$a\ ^3P_1 - z\ ^3P_1^0$	3	.20	.20	2.26, 2.46	2.46	2.26
6h	3046.67	32813.2	$a\ ^3P_2 - y\ ^3D_1^0$						

TABLE 1.—*Second spectrum of columbium* (Cb II)—Continued

Intensity spark	λ_{air} A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	8	10
150	3044.749	32833.90	$b\ ^3F_4-y\ ^3G^0_5$	2		0	1.193	(1.152)	1.160
10	3043.272	32849.84	$b\ ^3F_3-y\ ^3F^0_3$	3	0.11	0.22	.78	.84	.73
15	3042.790	32855.04	$b\ ^3F_3-y\ ^3F^0_3$	1	.362	0	.430	1.154	1.516
10c	3041.98	32863.8	$a\ ^3D_3-z\ ^3F^0_3$						
4	3040.54	32879.4	$a\ ^3D_3-z\ ^3S^0_1$						
150c	3039.818	32887.16	$a\ ^3P_2-z\ ^3P^0_2$	1		0	1.60	(1.663)	1.70
10	3039.398	32891.71	$a\ ^3F_4-z\ ^3D^0_3$	3	.141	.284	.992, 1.133	.992	1.133
200cR	3034.95	32939.9	$b\ ^1G_4-y\ ^1G^0_4$	7b		0	.950	.950	.950
4	3033.47	32956.0	$c\ ^3F_4-w\ ^3G^0_4$						
400rR	3032.767	32963.62	$a\ ^1G_4-z\ ^1H^0_5$	1		0	1.008	(1.052)	1.043
20	3029.86	32995.2	$a\ ^3P_1-y\ ^3D^0_2$	3	1.490	1.490	.983	2.473	.983
60	3029.76	32996.3	$b\ ^3F_2-z\ ^1F^0_3$	2	.24	0	1.57	.85	1.09
10	3028.76	33007.2	$c\ ^3F_3-e\ ^3D^0_3$						
200c	3028.436	33010.76	$a\ ^3F_4-z\ ^3D^0_3$	1		0	1.37	(1.350)	1.34
2h	3026.80	33028.6	$b\ ^1H_4-x\ ^1G^0_4$						
40	3025.372	33044.19	$c\ ^3F_2-w\ ^3G^0_3$	2	.205	0	1.282	.667	.872
250	3024.735	33051.15	$a\ ^3P_2-y\ ^3D^0_3$	1	.368	0	.706	1.810	1.442
10	3024.258	33056.36	$a\ ^3H_5-z\ ^3H^0_4$						
200	3022.738	33072.99	$b\ ^3H_4-x\ ^3H^0_4$	1		0	1.06	(1.154)	1.173
5	3022.48	33075.8	$b\ ^3G_3-w\ ^3F^0_3$						
8	3021.885	33082.31	$b\ ^3H_4-x\ ^3F^0_4$						
3	3019.780	33105.38	$b\ ^3G_4-y\ ^1G^0_4$						
8	3019.57	33107.7	$b\ ^3D_1-v\ ^3F^0_2$						
3	3019.20	33111.7	$a\ ^1D_2-y\ ^3P^0_1$						
6	3019.07	33113.2	$b\ ^3F_2-y\ ^3G^0_3$						
100	3018.853	33115.54	$b\ ^3H_4-x\ ^3G^0_4$	2		0	1.09	(.880)	.810
7	3018.31	33121.5							
2	3016.19	33144.8	$d\ ^3F_4-u\ ^3F^0_4$						
20	3015.82	33148.9	$d\ ^3F_3-u\ ^3F^0_3$						
20	3015.02	33157.6							
15	3014.438	33164.04	$a\ ^3F_4-z\ ^3D^0_3$	2	1.140	0	2.276	0.000	1.136
3	3013.62	33173.1							
25	3010.685	33205.38	$b\ ^3H_4-x\ ^3G^0_5$	3	.14	.70	1.12±	1.05	1.19
20	3010.38	33208.7	$b\ ^3G_4-y\ ^1G^0_4$	3		.28	.990±	1.025	.955
7	3008.97	33224.3	$a\ ^3D_1-z\ ^3F^0_2$						
20c	3008.39	33230.7	$a\ ^3P_2-z\ ^3P^0_2$	2	.59	0	2.39	1.80	1.21
4	3007.488	33240.68	$a\ ^3D_1-z\ ^3S^0_1$						
60	3005.764	33259.75	$b\ ^3H_5-x\ ^3F^0_4$	1		0	.40	(1.052)	1.215
10	3004.65	33272.1	$a\ ^1S_0-z\ ^1P^0_1$	7a		0	1.202	0/0	1.202
2h	3003.75	33282.0							
2h	3003.16	33288.6	$a\ ^3D_3-z\ ^3F^0_3$						
40	3002.204	33299.18	$a\ ^3P_1-y\ ^3D^0_1$	3	.630	1.886	1.035, 1.666	1.666	1.035
150	3001.85	33303.1							
50	3001.125	33311.16	$c\ ^3F_2-w\ ^3G^0_2$	2		0	1.025	(1.080)	1.066
4h	2998.87	33336.2							
1	2998.56	33339.6	$a\ ^1G_4-z\ ^1H^0_4$						
1	2997.947	33346.46	$b\ ^3D_3-y\ ^1F^0_3$						
8	2997.48	33351.7	$c\ ^3F_3-e\ ^3D^0_2$	2	.52	0		(.670)	1.19
1	2997.14	33355.4	$a\ ^1H_5-w\ ^3G^0_4$						
7	2996.79	33359.3	$a\ ^3H_4-z\ ^3H^0_4$	7b, 3		0	.818	(.825)	.811
4	2995.49	33373.8	$a\ ^3D_3-y\ ^3F^0_4$						
300c	2994.725	33382.34	$a\ ^3F_3-z\ ^3F^0_3$	2		0	1.60	(1.39)	1.34
20c	2993.97	33390.8	$a\ ^3P_2-z\ ^3P^0_2$						
20	2993.806	33392.59	$a\ ^1D_2-y\ ^3F^0_2$						
80	2991.956	33413.23	$a\ ^3P_1-z\ ^3P^0_1$	3	1.261	1.260	1.225, 2.487	2.486	1.225
6	2991.43	33419.1	$a\ ^3F_3-e\ ^3F^0_3$						
200c	2990.28	33432.0	$a\ ^3P_1-z\ ^3P^0_2$	3		.24	1.62±	1.66	1.56
40h	2989.944	33435.72							
9	2987.55	33462.5	$a\ ^1G_4-z\ ^1G^0_4$	7b		0	1.083	1.083	1.083
1	2987.16	33466.9	$c\ ^3F_3-e\ ^3D^0_3$						
3	2986.90	33469.8	$a\ ^3D_3-x\ ^3F^0_3$						
5h	2986.40	33475.4	$b\ ^3D_3-u\ ^3F^0_3$						
50	2985.04	33490.6	$a\ ^3D_3-y\ ^3F^0_2$	1	.253	0	.731	1.237	1.490
3	2982.90	33514.7	$c\ ^3F_3-e\ ^3D^0_2$						

TABLE 1.—*Second spectrum of columbium* (Cb II)—Continued

Intensity spark	λ_{air} A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest s	θ_1	θ_2
1	2	3	4	5	6	7	8	9	10
100	2982.100	33523.66	$a\ ^5F_3 - z\ ^5D_3^0$	3		0.17	1.28±	1.25	1.31
150	2980.717	33539.22	$a\ ^5D_2 - z\ ^5F_1^0$	2		0	1.23	(1.003)	1.079
80	2979.875	33548.69	$c\ ^5F_4 - w\ ^5G_3^0$	1		0	1.04	(1.240)	1.20
1	2979.50	33552.9	$b\ ^5F_1 - z\ ^5S_2^0$						
3	2979.34	33554.7							
80	2978.943	33559.19	$b\ ^5H_3 - z\ ^5G_3^0$	1	0.125	0	.552	1.052	1.177
2h	2978.09	33568.8	$b\ ^5D_1 - w\ ^5P_2^0$						
150c	2977.67	33573.5	$a\ ^5P_1 - z\ ^5P_2^0$	1	.732	0	1.015	2.479	1.747
2	2975.92	33593.3	$a\ ^5D_3 - z\ ^5S_2^0$						
10	2974.72	33606.8	$b\ ^3G_3 - y\ ^1G_4^0$	2	.19	0	1.53	.77	.96
400rs	2974.094	33613.90	$a\ ^3G_3 - z\ ^3H_4^0$	1		0	1.10	(1.180)	1.167
6	2973.32	33622.6	$b\ ^3F_3 - y\ ^3F_4^0$	2	.28	0		(.849)	1.13
200c	2972.568	33631.15	$a\ ^5P_3 - y\ ^5D_4^0$	1	.185	0	.920	1.660	1.475
10	2970.47	33654.9	$b\ ^3F_3 - y\ ^3H_4^0$	1	.19	0		(1.150)	.96
10	2970.40	33655.7	$a\ ^1D_2 - y\ ^3G_3^0$	7b		0	1.023	(1.003)	1.010
10	2968.29	33679.6	$b\ ^5F_4 - y\ ^5H_5^0$	3	.196	.784	1.06±	(1.152)	.956
3h	2967.93	33683.7	$b\ ^5D_3 - y\ ^5F_4^0$						
8c	2965.871	33707.09							
6	2965.63	33709.8	$a\ ^1G_4 - y\ ^3H_5^0$	1		0	.92	(1.083)	1.05
3	2964.958	33717.47							
15	2961.64	33755.2	$a\ ^3H_5 - z\ ^3H_6^0$	7b		0	1.040	1.040	1.040
3	2960.231	33771.31	$a\ ^1F_3 - v\ ^3F_4^0$						
20	2956.89	33809.5	$a\ ^3F_3 - z\ ^1D_2^0$	1	.240	0	.580	1.000	1.200
4h	2954.72	33834.3	$a\ ^3F_4 - z\ ^3F_4^0$						
20	2954.538	33836.28	$a\ ^1G_4 - w\ ^3F_4^0$	3		.098	1.09±	1.08	1.10
5	2954.03	33842.2	$b\ ^3P_2 - z\ ^1P_1^0$	7a		0	.934	0/0	.934
2	2953.384	33849.60	$b\ ^1G_4 - 5005$						
800R	2950.876	33878.37	$a\ ^3F_2 - z\ ^3F_3^0$	3		w	1.37±	(1.39)	1.35
4	2949.506	33894.10	$b\ ^3P_1 - z\ ^1P_1^0$	3	.552	.584	.935, 1.515	1.516	.934
80	2946.890	33924.19	$a\ ^3F_2 - z\ ^3D_3^0$	2	.310	0	1.930	1.000	1.310
60	2946.110	33933.17	$a\ ^5F_2 - z\ ^5F_3^0$	2	.25	0	1.76	1.26	1.21
100c	2945.890	33935.70	$a\ ^5P_1 - z\ ^5P_2^0$	1	.28	0	(1.82)	1.54	
500cR	2941.536	33985.94	$a\ ^5F_4 - z\ ^5F_4^0$	3		w	1.34±	(1.35)	1.33
4	2940.88	33993.5	$a\ ^1I_6 - z\ ^3I_7^0$						
100	2937.707	34030.23							
25	2937.327	34034.63	$a\ ^3G_5 - y\ ^1D_4^0$	7b		0	1.060	(1.052)	1.049
20	2936.67	34042.2	$d\ ^5F_5 - u\ ^5F_4^0$						
3	2936.50	34044.2							
20	2935.282	34058.34	$a\ ^3H_4 - z\ ^3H_4^0$	2	.203	0	1.855	.830	1.035
2	2933.43	34079.8	$a\ ^1D_2 - z\ ^3F_3^0$						
2	2933.17	34082.9	$d\ ^3F_2 - u\ ^3D_3^0$						
25	2932.658	34088.81	$a\ ^5P_2 - z\ ^5P_3^0$	3	.56	1.12	1.26, 1.82	1.82	1.26
30	2932.13	34095.0	$d\ ^5F_5 - s\ ^5G_4^0$						
70	2931.458	34102.77	$a\ ^5F_1 - z\ ^5F_1^0$	2	.879	0	1.870	.991	.112
3	2930.853	34109.80							
7	2930.648	34112.20							
60	2930.267	34116.62							
600cR	2927.804	34145.33	$a\ ^3F_3 - z\ ^1D_2^0$	1		0	.99	(1.39)	1.49
1	2926.08	34165.4	$a\ ^1D_2 - y\ ^3F_3^0$						
4	2925.93	34167.2	$a\ ^3G_4 - z\ ^3F_4^0$						
1h	2922.74	34204.5	$a\ ^3F_3 - z\ ^1D_2^0$						
6	2922.45	34207.9	$b\ ^3G_3 - z\ ^3D_3^0$						
3	2919.32	34244.6							
3	2918.92	34249.2	$a\ ^1D_4 - z\ ^3G_5^0$						
10	2918.56	34253.5							
100	2917.050	34271.20	$a\ ^3P_1 - z\ ^3P_2^0$	1	1.233	0	2.478	2.478	1.246
3	2916.40	34278.8	$b\ ^1G_4 - z\ ^3G_5^0$						
8c	2916.09	34282.5	$\begin{cases} a\ ^5P_3 - y\ ^3G_4^0 \\ b\ ^3H_5 - z\ ^1I_6^0 \end{cases}$						
10	2915.412	34290.45	$a\ ^3D_3 - y\ ^3H_4^0$	1	.29	0		(1.240)	.96
5h	2914.41	34302.2							

TABLE 1.—*Second spectrum of columbium* (Cb II)—Continued

Intensity spark	λ air A	Wave No. vac. cm⁻¹	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
2	2912.91	34319.9	$b\ ^3D_3-p\ ^1D_2$						
200*R*	2911.740	34333.70	$a\ ^3F_3-z\ ^3F_3$	3		w	1.01±	(0.996)	1.02
400*R*	2910.580	34347.38	$a\ ^3F_3-z\ ^3F_2$	3		w	1.20±	(1.25)	1.27
20	2908.98	34366.3	$b\ ^1G_4-z\ ^3G_3$						
10	2908.88	34366.8	$a\ ^1G_4-y\ ^1G_4$						
2*hr*	2908.236	34375.06	$a\ ^3F_4-z\ ^3F_4$	3		0	.12	0.000	.12
1	2907.206	34387.24	$b\ ^3F_3-w\ ^3F_3$						
6	2904.87	34414.9	$b\ ^3H_5-z\ ^1I_6$	1		0	.87	(1.052)	1.02
3	2904.13	34423.8	$a\ ^3G_5-z\ ^1H_5$						
2	2902.329	34445.02	$b\ ^3G_5-z\ ^3G_4$						
200*r*	2899.230	34481.83	$a\ ^3F_4-z\ ^3F_3$	7b, 2		0	1.374	(1.350)	1.355
200*R*	2897.803	34498.82	$a\ ^3F_3-z\ ^3F_2$	2		0	1.54	(1.248)	1.321
5	2895.39	34527.6	$a\ ^3F_3-y\ ^3F_3$	3		.10	1.024±	1.009	1.039
20*c*	2894.43	34539.0	$a\ ^3P_2-y\ ^3P_1$			0	1.82	(1.81)	1.80
5	2890.56	34582.2	$a\ ^1S_0-y\ ^1P_1$	7a		0	1.13	0/0	1.13
10	2890.350	34587.77	$b\ ^3F_4-z\ ^1G_4$	3		.25	1.12±	1.15	1.09
150*r*	2888.824	34606.04	$a\ ^3F_4-z\ ^3F_3$	2	1.028	0	2.057	0.001	1.029
10	2887.70	34619.5	$b\ ^3P_1-z\ ^3D_2$	1	.247	0	1.010	1.504	1.257
6	2887.088	34626.85	$a\ ^3F_3-y\ ^3D_3$	1	.674	0	0	.674	1.348
3	2886.61	34632.6	$b\ ^1G_4-z\ ^3G_4$						
7	2886.34	34635.8	$b\ ^3G_4-z\ ^1G_4$	2	.224	0		(1.027)	.803
1	2886.24	34637.0	$a\ ^3D_3-w\ ^3F_3$						
4*h*	2883.60	34668.7							
300*R*	2883.168	34673.92	$a\ ^3F_4-z\ ^3D_3$	1		0	.92	(1.35)	1.49
10	2882.471	34682.31	$c\ ^3P_1-z\ ^1D_2$	1	.21	0	.78	1.20	.99
2*h*	2881.84	34689.9							
100	2880.712	34703.49	$a\ ^3G_3-y\ ^3G_4$	2		0	1.40	(1.180)	1.125
15	2879.359	34719.79	$a\ ^3D_3-z\ ^3D_3$						
3	2879.21	34721.6	$a\ ^3P_1-y\ ^3P_1$						
9	2878.739	34727.27	$a\ ^3D_1-z\ ^3D_2$	3	1.077	1.082	.430, 1.502	1.505	.428
10	2877.85	34738.0	$a\ ^3G_4-z\ ^1H_5$						
10	2877.62	34740.8	$d\ ^3F_3-z\ ^3G_4$						
200*cR*	2877.026	34747.95	$a\ ^3F_3-z\ ^3F_3$	2	.274	0	1.825	1.003	1.277
150	2876.951	34748.85	$a\ ^3F_4-z\ ^3D_3$						
200*cR*	2875.386	34767.76	$a\ ^3F_3-z\ ^3D_2$	1	.225	0	.780	1.236	1.461
1	2874.98	34772.7	$b\ ^3D_3-p\ ^3D_2$						
7	2872.81	34798.9	$b\ ^3G_3-z\ ^3G_3$	7b, 2		0	1.178	(1.19)	1.17
1	2872.51	34802.6	$c\ ^3F_3-z\ ^3F_3$						
1	2871.91	34809.8	$a\ ^1D_2-z\ ^3S_1$ $b\ ^3H_4-e\ ^3F_3$						
2*h*	2871.06	34820.1	$a\ ^3P_2-y\ ^3F_3$						
2	2869.84	34835.0	$b\ ^3F_4-y\ ^3H_5$						
300*R*	2868.524	34850.93	$a\ ^3F_2-z\ ^3D_1$	1	.470	0	.523	.993	1.463
10*h*	2867.28	34866.0							
2	2866.86	34871.2	$a\ ^3P_2-y\ ^3D_2$						
60	2865.609	34886.38	$a\ ^3D_3-z\ ^3D_2$	7a		0	.413	0/0	.413
3	2861.66	34934.5							
100	2861.091	34941.46	$a\ ^3F_4-z\ ^3D_3$	*	0	0	0	0.000	0/0
2	2859.46	34961.4	$b\ ^3F_4-w\ ^3F_4$						
20	2859.038	34966.68	$a\ ^3P_2-z\ ^1F_3$	1	.72	0	.36	1.80	1.08
7	2857.363	34987.05	$b\ ^3H_5-v\ ^3F_4$						
8	2855.54	35009.4	$b\ ^3P_0-z\ ^3D_1$	7a		0	.821	0/0	.821
3	2855.082	35015.00							
3	2853.52	35034.2	$b\ ^3G_3-z\ ^3G_3$						
1	2851.82	35055.1	$b\ ^3P_2-w\ ^3D_2$						
5	2851.295	35061.50	$b\ ^3P_1-z\ ^3D_1$						
4	2850.385	35072.70	$b\ ^3P_2-w\ ^3D_1$						
100*c*	2849.557	35082.89	$a\ ^3D_3-z\ ^3D_3$						
20	2848.296	35098.42	$b\ ^3P_2-z\ ^3D_3$						
6	2848.02	35101.8	$a\ ^1I_6-z\ ^3G_5$						
15	2847.23	35111.6	$b\ ^3P_2-w\ ^3D_3$	3	.32	.63	1.17, 1.49	1.49	1.17

*Unaffected by magnetic field.

TABLE 1.—*Second spectrum of columbium* (Cb II)—Continued

Intensity spark	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
60	2846.280	35123.28	$a\ ^3F_3-z\ ^3D_3^0$	3	1.463	1.464	0, 1.462	0.000	1.463
20	2845.798	35129.23	$a\ ^3H_4-y\ ^3D_3^0$	1	.205	0	.205	.820	1.025
40	2844.428	35146.14	$b\ ^3P_1-w\ ^3D_2^0$	1	.335	0	.826	1.496	1.161
20	2843.640	35155.88	$a\ ^3H_3-z\ ^1H_4^0$						
3A	2843.41	35158.7							
100r	2842.642	35168.22	$a\ ^3F_2-z\ ^3D_2^0$	3	.472	.946	.994, 1.465	.994	1.466
80c	2841.141	35186.80	$a\ ^3F_3-z\ ^3D_3^0$	3	.209	.630	1.247, 1.462	1.250	1.460
1	2840.57	35193.9	$a\ ^1F_3-w\ ^3G_4^0$						
6	2839.79	35203.5	$b\ ^3P_2-w\ ^3D_2^0$						
7A	2839.62	35205.7	$a\ ^3F_3-y\ ^3P_2^0$						
3A	2838.45	35245.0	$b\ ^3H_4-527\frac{1}{2}$						
4	2836.079	35249.60							
50	2835.106	35261.70	$a\ ^3F_2-z\ ^3D_1^0$	2	.230	0	2.170	1.230	1.490
8	2833.312	35284.03	$a\ ^1P_1-z\ ^1D_2^0$						
10A	2832.78	35290.6							
3	2830.85	35314.7	$a\ ^3G_4-y\ ^3G_3^0$	2		0	1.11	(1.052)	1.03
20	2830.56	35318.3	$b\ ^3H_4-y\ ^1H_5^0$						
15	2829.750	35328.44	$a\ ^3D_4-z\ ^3D_3^0$	2	.180	0	2.058	1.502	1.322
3	2827.93	35351.2	$a\ ^1S_0-y\ ^3S_1^0$						
2	2827.79	35352.9	$b\ ^3D_1-x\ ^3D_2^0$						
30	2827.08	35361.8	$a\ ^3D_1-z\ ^3D_2^0$	1	.353	0	.775	1.481	1.128
4A	2826.97	35363.2	$b\ ^3H_4-y\ ^1H_5^0$						
2	2826.044	35374.77	$a\ ^3G_3-y\ ^3G_3^0$						
8	2825.86	35377.1	$a\ ^3G_3-y\ ^3F_4^0$	2		0	1.42	(1.18)	1.12
2	2824.863	35389.55	$a\ ^3F_3-y\ ^3D_3^0$						
10	2823.89	35401.7	$a\ ^3D_1-z\ ^1P_1^0$	3	.423	.425	.510, .931	.510	.933
10	2823.34	35408.6	$a\ ^3G_3-y\ ^3F_3^0$	7b, 2		0	.780	(.765)	.757
12	2820.803	35440.49	$a\ ^5F_1-z\ ^5D_0^0$	2	1.472	0	2.944	0.000	1.472
15	2819.893	35451.92							
1	2818.617	35467.97	$b\ ^3F_3-y\ ^1G_4^0$						
20c	2818.199	35473.23							
30	2816.678	35492.39	$b\ ^3F_4-y\ ^1G_4^0$	3	.20	.82	.95, 1.15	1.15	.95
20	2815.399	35508.51							
15	2811.70	35555.2	$b\ ^3F_3-z\ ^3D_3^0$	1		0	.97	(1.150)	1.24
100	2810.810	35566.48	$a\ ^3F_4-z\ ^5D_4^0$	1us					
4	2809.666	35580.96	$a\ ^3G_3-y\ ^3G_4^0$	7b		0	1.18	1.18	1.18
8	2809.172	35587.22	$a\ ^3F_2-z\ ^3D_1^0$	2	.461	0	2.388	1.005	1.466
6	2808.74	35592.7	$a\ ^3P_2-y\ ^3F_3$						
15A	2806.013	35615.86							
8A	2805.98	35627.7							
3	2805.83	35629.6							
15	2803.810	35655.27	$a\ ^3F_3-z\ ^3G_3^0$	3	.486	1.437	760, 1.248	1.248	.760
2	2802.73	35669.0	$b\ ^3P_1-z\ ^3P_0^0$						
7	2801.551	35684.02							
5	2799.180	35714.24	$b\ ^3F_4-z\ ^1P_1^0$						
25	2798.903	35717.78	$a\ ^3F_3-y\ ^3D_3^0$	1	.28	0	.51	1.07	1.35
100c	2797.693	35733.22	$a\ ^3P_2-z\ ^3S_1^0$	1	.275	0	1.11c	1.660	1.935
15	2795.14	35765.9	$a\ ^3D_3-z\ ^3D_3^0$	3	.250	.510	1.014, 1.260	1.010	1.260
7	2793.885	35781.92							
3	2793.687	35784.46	$a\ ^3F_3-y\ ^3D_2^0$						
80	2793.044	35792.70	$a\ ^3F_4-z\ ^3G_4^0$	3	.270	1.080	1.082, 1.350	1.350	1.083
80	2791.742	35809.39	$a\ ^3H_4-y\ ^3G_4^0$	1		0	.75	(1.050)	1.125
5	2791.372	35814.14	$b\ ^3P_2-z\ ^3P_1^0$	2	.28	0		(1.483)	1.205
10	2790.580	35824.30	$a\ ^3G_4-y\ ^3F_4^0$	1		0	.84	(1.052)	1.123
8	2789.76	35834.8							
3	2788.687	35848.62	$b\ ^3P_1-z\ ^3P_1^0$						
6	2785.071	35895.16	$a\ ^3G_4-y\ ^3G_4^0$						
3	2784.450	35903.16							
4	2782.807	35924.36	$b\ ^3P_2-z\ ^3G_3^0$						
4	2780.985	35947.90							
150c	2780.235	35957.59	$a\ ^3F_3-z\ ^3G_4^0$	3		.80	1.31±	1.39	1.23
3	2778.018	35986.29	$a\ ^3F_3-z\ ^3D_3^0$						
6A	2775.758	36015.58							
5	2774.488	36032.07	$b\ ^3D_1-z\ ^1D_2^0$	2	.314	0		(1.312)	.998
20	2771.65	36069.0	$b\ ^3F_3-z\ ^3D_2^0$	3		.41	1.21±	1.14	1.28

TABLE 1.—*Second spectrum of columbium* (Cb II)—Continued

Intensity spark	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
80	2771.398	36072.24	$a\ ^1H_5 - x\ ^1G^0_4$	7b, 1		0	0.985	0.992	0.994
1	2769.765	36093.51	$b\ ^3F_4 - x\ ^3D^0_3$						
10	2769.561	36096.17	$a\ ^3G_3 - z\ ^3F^0_2$	2	0.336	0	1.447	.775	.439
6	2769.290	36099.70							
10hrv	2768.124	36114.90	$a\ ^3D_2 - z\ ^3D^0_1$	1	.185	0	.935	1.400	1.305
5	2767.218	36126.73	$a\ ^3D_1 - z\ ^3D^0_2$	2	.75	0		(.512)	1.262
6	2765.952	36143.26	$a\ ^3F_3 - y\ ^3D^0_2$	1	.27	0	.44	.71	.98
9	2765.271	36152.16	$a\ ^3D_1 - z\ ^3F^0_2$	2	.23	0	2.18	1.49	1.26
10	2764.561	36161.45	$a\ ^3D_2 - z\ ^3F^0_3$	2	.466	0	2.410	1.478	1.012
15	2763.59	36174.2	$b\ ^3F_3 - w\ ^3D^0_2$	3	.17	.50		(1.15)	1.32
1	2763.025	36181.55	$a\ ^3G_3 - y\ ^3F^0_3$						
3	2762.49	36188.6	$a\ ^3P_2 - z\ ^3P^0_1$						
6	2762.32	36190.8	$a\ ^3D_2 - x\ ^3D^0_2$	7b, 1		0	1.240	(1.246)	1.249
2	2761.737	36198.42	$b\ ^3F_4 - w\ ^3D^0_3$						
2h	2759.968	36221.62							
5	2759.16	36232.2	$b\ ^3H_4 - w\ ^3G^0_3$						
20c	2758.78	36237.2	$a\ ^3P_2 - z\ ^3S^0_1$	3us					
10	2757.50	36254.0	$a\ ^3D_3 - w\ ^3D^0_2$	2	.387	0	1.394	1.007	.620
40	2757.256	36257.25	$a\ ^1D_2 - z\ ^1P^0_1$	2		0	1.062	(1.003)	.944
3c	2755.722	36277.43							
5	2755.562	36279.53	$a\ ^3D_3 - x\ ^3D^0_3$						
40	2754.523	36293.22	$a\ ^3D_3 - z\ ^3F^0_4$						
3	2753.74	36303.5	$a\ ^3D_4 - z\ ^3F^0_4$						
5	2753.56	36305.9	$a\ ^3F_3 - z\ ^3G^0_4$						
100c	2753.133	36311.54	$a\ ^1I_5 - z\ ^1I^0_5$	7b, 3		0	1.003	1.000	1.006
3	2752.63	36318.2	$a\ ^3F_4 - y\ ^3D^0_3$						
6	2752.02	36326.2	$a\ ^3F_3 - z\ ^3P^0_2$	1	.68	0	.36	1.04	1.72
15	2750.58	36345.2	$a\ ^3G_4 - z\ ^3F^0_3$	2		0	1.22	(1.052)	1.00
5	2749.817	36355.33	$a\ ^3F_3 - z\ ^3F^0_3$	3	.30	.62	.69, .99	.99	.69
4	2749.69	36357.0	$a\ ^3P_2 - y\ ^3D^0_3$	3		.20		(1.450)	1.35
7	2748.077	36378.34	$b\ ^3F_3 - 5001^0_3$	3		.27		(1.150)	1.24
5	2747.606	36384.58	$a\ ^3D_2 - w\ ^3D^0_3$						
3	2747.378	36387.64	$a\ ^3P_2 - y\ ^3D^0_2$	2	.46	0		(1.450)	.99
40	2745.725	36409.51	$a\ ^3H_4 - y\ ^3G^0_3$	1	.196	0	.229	.818	1.014
20c	2745.303	36415.10	$a\ ^3F_3 - z\ ^3F^0_4$						
20c	2744.97	36419.5	$a\ ^3P_1 - z\ ^3S^0_1$						
4	2744.448	36426.64	$a\ ^3G_4 - y\ ^3H^0_4$						
8	2743.478	36439.32	$b\ ^3F_3 - z\ ^3D^0_3$	3	.413	.824	.840, 1.254	.840	1.254
4	2742.604	36450.94	$a\ ^3F_4 - z\ ^3P^0_2$	1	.33	0	.24	1.23	1.56
100	2740.185	36483.11	$a\ ^3H_5 - y\ ^3F^0_4$	1		0	.81	(1.050)	1.11
5	2739.239	36495.71	$b\ ^1G_4 - 5271^0_4$	1	.465	0		(.950)	1.415
60	2737.083	36524.46	$a\ ^3D_2 - z\ ^3F^0_2$	3	.468	.936	1.023, 1.487	1.488	1.020
7c	2736.521	36531.96							
5	2735.948	36539.61	$b\ ^3H_4 - v\ ^3D^0_3$	1	.32	0		(.88)	1.20
4	2734.733	36555.84	$b\ ^3P_1 - y\ ^1D^0_2$						
15	2734.36	36560.8	$a\ ^3F_2 - z\ ^3P^0_1$	1	.50	0	.22	.72	1.2
15	2733.74	36569.1	$a\ ^3D_1 - z\ ^3D^0_1$						
			$b\ ^1G_4 - y\ ^1H^0_5$						
8	2733.464	36572.79	$a\ ^3D_1 - z\ ^3F^0_1$	7a		0	1.500	1.500	0.000
40hrv	2733.258	36575.57	$a\ ^3D_2 - z\ ^3F^0_3$	3	.227	.690	1.266, 1.483	1.487	1.260
2	2732.25	36589.1	$a\ ^3D_3 - 5001^0_3$						
60	2730.324	36614.87	$a\ ^3D_1 - w\ ^3D^0_1$	3	.10	.10	.56±	.51	.61
2	2729.524	36625.60	$a\ ^3P_2 - y\ ^3D^0_1$	1		0	1.39	(1.45)	1.43
5	2729.372	36627.64	$a\ ^3F_4 - z\ ^3F^0_3$						
8	2727.43	36653.7	$a\ ^3D_1 - w\ ^3D^0_2$	2	.652	0	1.622	.518	1.170
6	2724.95	36687.1	$a\ ^3H_5 - y\ ^3G^0_4$						
60	2723.660	36704.45	$a\ ^3D_3 - x\ ^3D^0_3$	3		.13	1.26±	1.24	1.28
6	2722.69	36717.5	$a\ ^3D_3 - w\ ^3D^0_3$						
150hrv	2721.987	36727.01	$a\ ^3D_3 - z\ ^3F^0_4$	1	.170	0	.803	1.483	1.313
8	2721.632	36731.80	$a\ ^3D_3 - z\ ^3F^0_2$						
6	2721.162	36738.14	$a\ ^3F_3 - y\ ^3D^0_3$	3		.09	1.06±	1.08	1.04

TABLE 1.—*Second spectrum of columbium* (Cb II)—Continued

Intensity spark	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
6	2720.95	36741.0	$a\ ^3G_4 - y\ ^3H_3^0$	3		0.36		(1.052)	0.96
7	2720.259	36750.34	$a\ ^3F_3 - z\ ^3F_3^0$	3	0.16	.48		(1.25)	1.09
8	2717.63	36785.9	$a\ ^3H_4 - y\ ^3F_4^0$	3	.288	1.154	82, 1.11	.82	1.11
10	2717.33	36790.0				0	1.193		
150*rs*	2716.630	36799.43	$a\ ^3D_1 - z\ ^3F_2^0$	1	.14	0	.80	1.50	1.36
15	2716.309	36803.77	$a\ ^3D_1 - z\ ^3F_1^0$	1	.47	0	.55	1.49	1.02
40	2715.882	36809.56	$a\ ^3D_3 - w\ ^3D_3^0$	3		.18	1.28	1.25	1.31
50	2715.344	36816.85	$b\ ^1G_4 - y\ ^1F_3^0$	1		0	.67	(.95)	1.04
2	2713.74	36838.6	$b\ ^3G_4 - y\ ^1H_5^0$						
5	2711.37	36870.8	$a\ ^3F_3 - z\ ^3F_2^0$						
3	2709.595	36894.96	$b\ ^3F_3 - z\ ^3G_3^0$						
2	2709.07	36902.1	$b\ ^3D_1 - z\ ^1D_2^0$						
20	2707.834	36918.96	$a\ ^3H_4 - y\ ^3F_4^0$	1	.295	0	−.07	.815	1.11
3	2707.212	36927.44	$b\ ^3F_3 - w\ ^3D_2^0$	2	.23	0		(.85)	.62
20	2706.395	36938.58	$a\ ^3D_3 - z\ ^3F_3^0$	1	.22	0	.82	1.48	1.26
4	2705.326	36953.18	$b\ ^3F_3 - z\ ^3D_3^0$	2	.45	0		(.85)	1.30
3	2704.92	36958.7	$b\ ^3H_4 - w\ ^3G_3^0$						
5	2704.70	36961.7							
5	2704.417	36965.60	$a\ ^3P_2 - z\ ^3P_2^0$						
20	2704.260	36967.88	$a\ ^3D_3 - z\ ^3P_2^0$	3	.352	.714	1.010, 1.355	1.006	1.358
40	2702.521	36991.53	$a\ ^3D_4 - z\ ^3D_3^0$	2		0	1.545	(1.495)	1.478
60*rs*	2702.197	36995.97	$a\ ^3D_3 - z\ ^3D_2^0$	2		0	1.519	(1.486)	1.460
10	2700.872	37014.12	$a\ ^3D_3 - 5001$	7b, 3		0	1.255	(1.25)	1.26
7	2700.555	37018.46	$a\ ^3F_4 - z\ ^3F_3^0$	3		.30	1.30±	1.34	1.26
3	2700.312	37021.79	$a\ ^3F_4 - z\ ^3H_5^0$						
15	2700.183	37023.97	$a\ ^3F_3 - z\ ^3P_2^0$	1	.180	0	.702	1.062	1.242
100*rs*	2698.866	37041.62	$a\ ^3D_3 - z\ ^3D_3^0$	2		0	1.508	(1.490)	1.472
2	2697.66	37058.2	$b\ ^3F_3 - w\ ^3D_3^0$						
200*Rs*	2697.067	37066.33	$a\ ^3D_3 - z\ ^3D_3^0$	3		.20	1.475±	1.50	1.45
3	2695.601	37086.49	$b\ ^3G_4 - y\ ^1F_3^0$						
4	2694.753	37098.16	$a\ ^3P_1 - y\ ^3D_2^0$ $a\ ^3G_3 - y\ ^3H_4^0$						
4	2694.316	37104.18							
3	2692.652	37127.10	$b\ ^3P_2 - y\ ^1P_1^0$						
10	2692.002	37136.07	$b\ ^3H_4 - w\ ^3G_3^0$	7b, 1		0	1.024	(1.052)	1.080
60*rs*	2691.774	37139.22	$a\ ^3D_1 - z\ ^3D_2^0$	7a		0	1.496	1.496	0/0
4	2690.930	37150.86	$a\ ^3F_2 - z\ ^3F_2^0$	2		0	1.24	(.996)	1.08
2	2690.150	37161.63	$b\ ^3P_1 - y\ ^1P_1^0$	3	.38	.38		(1.504)	1.120
4	2689.066	37176.61	$a\ ^3D_1 - z\ ^3P_1^0$	7a	.500	0	.500	.500	0/0
100	2686.388	37213.67	$a\ ^1F_3 - z\ ^1D_2^0$	7b, 2		0	1.020	(1.007)	1.000
6	2683.216	37257.66	$a\ ^3P_1 - z\ ^3P_1^0$	3	.756	.756	1.490, 2.245	1.490	2.246
1	2682.849	37262.76	$b\ ^3F_3 - 5009$						
8	2682.469	37268.03							
1	2681.066	37287.54	$a\ ^3P_2 - w\ ^3F_3^0$						
50	2680.061	37301.52	$a\ ^3F_4 - y\ ^3G_4^0$	3		.40	1.18±	1.23	1.13
15	2678.663	37320.98	$a\ ^3D_1 - z\ ^3D_1^0$	7b, 3		0	1.470	1.500	1.440
6	2678.102	37328.80	$a\ ^3D_1 - z\ ^3P_2^0$	2	.86	0		(.512)	1.37
15	2677.664	37334.91	$a\ ^3G_3 - z\ ^1G_4^0$	2		0	1.57	(1.18)	1.08
5	2676.124	37356.30	$a\ ^3D_1 - z\ ^3P_1^0$	3	.71	.71	.50, 1.21	.50	1.21
80*rs*	2675.945	37358.89	$a\ ^3D_3 - z\ ^3D_2^0$	7b, 3		0	1.480	(1.490)	1.470
2A	2675.104	37370.63	$a\ ^1P_1 - u\ ^1F_3^0$						
3A	2674.840	37374.32							
250*rs*	2673.566	37392.13	$a\ ^1I_6 - y\ ^1H_5^0$	7b, 1		0	.985	(1.000)	1.003
200*rs*	2671.933	37414.98	$a\ ^3D_3 - z\ ^3D_3^0$	3		.12	1.476±	1.496	1.456
2	2671.656	37418.86	$a\ ^3F_2 - z\ ^3P_1^0$						
12	2671.255	37424.48	$a\ ^1D_2 - z\ ^3D_1^0$	2	.19	0	1.19	1.00	.81
3	2670.152	37439.94	$a\ ^3H_4 - x\ ^3F_3^0$						
5	2668.501	37463.10							
4	2667.996	37470.19	$a\ ^1D_2 - w\ ^3D_1^0$						
35	2667.765	37473.43	$a\ ^3G_4 - w\ ^3F_3^0$	7b, 1		0	1.017	(1.052)	1.084
30	2667.300	37479.97	$a\ ^3D_3 - z\ ^3D_1^0$	7a		0	1.457	0/0	1.457
6	2667.146	37482.13	$a\ ^3F_4 - z\ ^1F_3^0$						
5	2667.072	37483.17	$b\ ^1G_4 - w\ ^3G_3^0$						
50	2666.595	37489.87	$a\ ^3D_3 - z\ ^3D_3^0$	7b, 1		0	1.437	1.496	1.474
2	2666.184	37496.94	$a\ ^1D_2 - z\ ^3D_2^0$						

TABLE 1.—*Second spectrum of columbium* (Cb II)—Continued

Intensity spark	λ air Å	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	8	10
2	2666.056	37497.45	$a\ ^3D_3-x\ ^3F_4^1$						
60	2665.247	37508.83	$a\ ^3G_3-w\ ^3F_3^1$	2	0.142	0	1.057	0.773	0.631
3	2664.010	37526.25	$a\ ^3G_4-x\ ^3H_5^1$						
2	2663.705	37530.55	$a\ ^3D_3-x\ ^3G_4^1$						
10	2663.552	37532.70	$a\ ^3H_5-y\ ^3H_5^1$			0	1.34	(1.050)	.98
15	2660.036	37582.31	$a\ ^3G_3-y\ ^3H_4^1$	3		.70	1.11±	1.18	1.04
15	2659.049	37596.26	$b\ ^3H^4-w\ ^3G_4^1$	1		0	1.10	(1.154)	1.165
5	2658.875	37598.72	$a\ ^3F_4-y\ ^3G_4^1$	2	.22	0		(1.230)	1.01
1	2658.711	37601.04	$a\ ^1D_2-w\ ^3D_3^1$						
80rs	2656.076	37638.34	$a\ ^3D_1-z\ ^3D_2^1$	7b, 1		0	1.458	(1.500)	1.479
8	2655.865	37641.33	$b\ ^3F_2-x\ ^3P_1^1$	3	.50		.86, 1.36	.86	1.36
2	2655.314	37649.14	$a\ ^3G_4-z\ ^1G_4^1$						
10	2651.810	37698.88	$a\ ^3G_3-z\ ^3H_4^1$	1		0	.44	(1.180)	1.06
80	2651.122	37708.67	$a\ ^3G_3-w\ ^3F_2^1$	2		0	1.46	(1.180)	1.11
3	2649.714	37728.70	$b\ ^3H_4-w\ ^3G_5^1$						
3	2648.034	37752.64	$b\ ^3G_4-w\ ^3G_3^1$						
200rs	2646.258	37777.97	$a\ ^1D_2-z\ ^1D_2^1$	7b, 1		0	1.422	(1.490)	1.467
3	2644.932	37796.91	$a\ ^1D_2-z\ ^3G_3^1$						
5	2642.566	37830.75	$a\ ^3G_3-w\ ^3F_4^1$						
150rs	2642.233	37835.52	$a\ ^3H_4-y\ ^3H_4^1$	3	.120	.53	.824, .950	.822	.952
10	2641.060	37852.32	$a\ ^3G_3-y\ ^3H_3^1$	1		0	.93	(1.180)	1.14
5	2639.883	37869.20	$a\ ^3F_3-y\ ^3P_2^1$						
2	2639.420	37875.84	$b\ ^3P_0-y\ ^3S_1^1$						
5	2638.877	37883.62	$a\ ^1D_2-z\ ^3G_4^1$						
7	2638.591	37887.74	$a\ ^3P_2-z\ ^3P_1^1$	7a		0	2.256	0/0	2.256
10	2637.976	37896.57	$a\ ^3G_4-y\ ^3H_5^1$	7b, 1		0	1.016	(1.052)	1.045
3h	2635.837	37927.32	$c\ ^3F_4-u\ ^3F_4^1$						
60	2632.510	37975.25	$a\ ^3F_4-y\ ^3F_4^1$	3		.47	1.17±	1.23	1.11
3	2631.442	37990.67	$b\ ^3H_4-x\ ^1F_3^1$						
20	2630.983	37997.29	$a\ ^1G_4-y\ ^1H_5^1$						
1	2630.354	38006.37	$a\ ^3G_3-z\ ^1G_4^1$						
3	2629.209	38022.93	$a\ ^3G_4-w\ ^3F_4^1$	3		.20		(1.052)	1.10
3	2628.408	38034.51	$a\ ^3P_1-z\ ^3P_1^1$						
3c	2627.055	38054.10	$b\ ^3P_2-527\frac{1}{2}$						
4	2626.636	38060.17	$b\ ^3G_4-x\ ^3D_3^1$						
4	2626.401	38063.58	$a\ ^1D_2-y\ ^1D_2^1$	2	.45	0	1.44	.54	.99
2	2624.330	38093.61	$a\ ^3P_1-z\ ^3P_0^1$						
6	2623.321	38108.26	$a\ ^3F_4-y\ ^3F_3^1$						
5	2623.170	38110.46	$a\ ^1D_2-z\ ^3G_3^1$						
20	2622.952	38113.62	$a\ ^3P_2-y\ ^3P_1^1$	1	.30	0	1.14	1.44	1.74
80	2620.440	38150.16	$a\ ^3F_3-y\ ^3F_4^1$	7b, 3		0	.726	(.712)	.740
3	2618.444	38179.24	$a\ ^3F_4-y\ ^3G_5^1$						
10	2617.427	38194.07	$c\ ^3P_2-u\ ^3D_3^1$						
2h	2617.102	38198.81							
15	2616.219	38211.70	$a\ ^1D_2-z\ ^3P_1^1$	1	.18	0	.83	1.01	1.19
10	2614.759	38233.04	$c\ ^3F_4-u\ ^3D_3^1$						
8	2614.306	38239.66	$a\ ^3G_4-y\ ^1G_4^1$	2	.232	0		(1.180)	.948
6	2613.927	38245.21	$a\ ^1G_4-y\ ^1F_3^1$						
8	2613.854	38246.27	$[a\ ^1D_2-z\ ^3G_4^1$						
			$[b\ ^3F_4^1-y\ ^3F_4^1$						
2	2609.622	38308.30	$a\ ^1D_2-y\ ^1P_1^1$						
1	2609.199	38314.51	$a\ ^3H_5-y\ ^3H_4^1$						
10	2608.958	38318.04	$a\ ^3H_4-z\ ^3I_5^1$	3	.18	.90		(1.050)	.87
2	2608.690	38321.98	$a\ ^1D_2-z\ ^3G_5^1$						
5	2605.064	38375.32	$b\ ^3P_1-y\ ^1F_3^1$						
10	2605.013	38376.07	$b\ ^3F_2-y\ ^1D_2^1$	3		.22		(.849)	.96
10c	2604.753	38379.90	$a\ ^3G_3-w\ ^3F_3^1$						
10	2603.731	38394.96	$a\ ^3F_3-y\ ^3F_4^1$	2		0	1.18	(1.070)	1.10
4	2602.485	38413.34	$a\ ^3F_3-y\ ^3G_4^1$	2	.305	0		(.712)	1.017
100	2601.283	38431.06	$a\ ^3H_6-z\ ^3I_6^1$	3		.62	1.10±	1.15	1.05
2	2600.615	38440.96	$a\ ^3H_5-z\ ^1G_4^1$						
10	2600.156	38447.75	$a\ ^3D_2-y\ ^3F_3^1$	3	.20	.40		(1.002)	.80
2h	2599.522	38457.13	$a\ ^3D_2-y\ ^1F_3^1$						
6	2598.037	38479.11	$b\ ^3G_4-w\ ^3G_4^1$	3		.13	1.043±	(1.027)	1.059
4c	2594.964	38524.67	$a\ ^3P_1-w\ ^3D_2^1$						
30	2594.736	38528.06	$a\ ^3F_3-y\ ^3F_4^1$	3		.15	1.094±	1.069	1.119

TABLE 1.—*Second spectrum of columbium* (Cb II)—Continued

Intensity spark	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g 1	g 2
1	2	3	4	5	6	7	8	9	10
10	2594.337	38533.98	$a\ ^3D_3-z\ ^3G^0_4$						
4	2592.035	38568.20	$a\ ^3H_4-w^3\ F^0_3$						
200*R*	2590.940	38584.50	$a\ ^3H_5-y\ ^3H^0_5$	3		0.18	1.14±	1.155	1.125
8	2588.966	38613.92	$b\ ^3F_4-p\ ^3F^0_4$						
4	2587.952	38629.04	$a\ ^3F_4-z\ ^3F^0_4$	2	0.22	0		(1.230)	1.01
8	2587.409	38637.15	$a\ ^1F_3-z\ ^1G^0_4$	7b, 1		0	.995	(1.007)	1.006
4	2586.911	38644.59	$a\ ^3F_3-y\ ^3F^0_3$	1	.445	0		(1.070)	1.515
250*R*	2585.962	38658.39	$a\ ^3H_5-y\ ^3H^0_5$	7b, 3		0	1.037	(1.050)	1.026
30	2580.284	38743.83	$a\ ^3H_4-z\ ^1G^0_4$	3	.26	1.04	0.83, 1.08	.83	1.08
6	2575.968	38808.74	$a\ ^3D_1-p\ ^3F^0_2$	2	.30	0	1.10	.50	.80
2	2575.570	38814.74	$a\ ^3H_5-w\ ^3F^0_4$						
40	2574.843	38825.70	$a\ ^3D_1-z\ ^3F^0_2$						
5	2574.074	38837.30	$a\ ^3F_3-z\ ^3F^0_3$	3	.29	.58		(.712)	.42
15	2573.136	38851.45	$c\ ^3F_3-p\ ^3G^0_4$						
5	2573.022	38853.18	$a\ ^3F_3-z\ ^3S^0_1$						
1h	2571.74	38872.5	$a\ ^3D_3-p\ ^3F^0_3$						
60	2571.324	38878.83	$a\ ^3D_4-z\ ^3G^0_5$	1	.264	0	.176	1.496	1.232
3	2569.187	38911.17	$a\ ^1G_4-w\ ^3G^0_5$ $a\ ^3G_3-y\ ^1G^0_4$						
2	2568.677	38918.89	$a\ ^1D_2-y\ ^1D^0_2$						
10	2568.409	38922.95	$a\ ^3F_3-y\ ^3F^0_4$						
5	2566.075	38958.35	$a\ ^3H_5-z\ ^3H^0_6$						
4	2565.675	38964.42	$c\ ^3F_3-u\ ^3D^0_3$						
20	2565.504	38967.02	$c\ ^3F_4-p\ ^3G^0_4$						
15	2564.846	38977.02	$c\ ^3F_3-p\ ^3G^0_3$	7b, 2		0	1.13	(1.08)	1.09
1	2564.526	38981.89	$b\ ^3F_3-y\ ^1F^0_3$						
15	2564.070	38988.81	$b\ ^3D_1-u\ ^3F^0_2$	2	.29	0		(.681)	.97
10	2563.913	38991.20	$a\ ^3H_4-y\ ^3H^0_4$						
120	2562.402	39014.19	$a\ ^3P_1-y\ ^3P^0_2$	7a		0	1.500	1.500	0/0
1	2561.926	39021.45	$a\ ^1H_5-p\ ^1G^0_4$						
6	2561.708	39024.76	$a\ ^3F_4-y\ ^3H^0_4$						
2c	2561.465	39028.46	$a\ ^3P_2-w\ ^3D^0_3$						
3	2560.741	39039.50	$a^3\ F_3-y\ ^3P^0_2$						
20	2560.622	39041.31	$b\ ^3P_2-w\ ^3G^0_3$	1	.592	0	.300	1.484	.892
60	2560.112	39049.09	$a\ ^3F_3-x\ ^1F^0_3$						
3	2558.628	39071.74	$b\ ^3G_4-w\ ^3G^0_5$						
120	2556.933	39097.63	$a\ ^3P_2-z\ ^3S^0_1$	1	.368	0	1.079	1.447	1.815
60	2555.626	39117.63	$a\ ^3H_4-w\ ^3F^0_4$	3	.277	1.114	.828, 1.099	.825	1.102
8	2555.314	39122.40	$b\ ^3F_4-y\ ^1H^0_5$						
8	2554.793	39130.38	$b\ ^3F_3-p\ ^3F^0_3$	2	.24	0	1.57	.85	1.09
15	2553.490	39150.35	$b\ ^3D_3-u\ ^3F^0_3$	2		0	1.411	(1.171)	1.231
120	2551.382	39182.60	$a\ ^3P_1-y\ ^3P^0_1$	3	.264	.266	1.498, 1.760	1.497	1.761
2	2550.037	39203.36	$a\ ^3H_4-z\ ^3I^0_5$						
2h	2549.435	39212.62	$a\ ^3P_2-x\ ^3F^0_3$						
1	2549.039	39218.70	$a\ ^1G_4-p\ ^3D^0_3$						
30	2548.634	39224.94	$a\ ^3D_3-p\ ^3F^0_4$	7b, 2		0	1.282	(1.246)	1.254
2	2547.556	39241.53	$b\ ^1G_4-x\ ^1F^0_3$						
2	2546.353	39260.07	$a\ ^3G_4-w\ ^3D^0_3$						
2	2545.404	39274.71	$c\ ^3P_2-u\ ^3D^0_2$						
200*R*	2544.802	39284.00	$a\ ^3P_2-y\ ^3P^0_2$	3		.102	1.480±	1.454	1.503
1	2544.435	39289.66	$a\ ^3G_3-495^0_4$						
50	2541.424	39336.21	$a\ ^5D_4-z\ ^5F^0_5$	3	.235	.94	1.200, 1.495	1.495	1.260
2	2541.074	39341.63	$a\ ^5D_3-z\ ^5F^0_4$						
3	2540.811	39345.70	$b\ ^3F_3-y\ ^1F^0_3$ $a\ ^3H_5-y\ ^1G^0_4$						
80	2540.611	39348.80	$b\ ^3P_2-p\ ^3D^0_3$	1	.273	0	.66	1.479	1.206
10	2539.224	39370.29	$b\ ^3F_4-y\ ^1F^0_3$						
10h	2534.445	39444.52	$a\ ^3F_3-y\ ^3H^0_4$						
30	2533.188	39464.08	$b\ ^3P_2-p\ ^3D^0_2$	3	.30	.60		(1.483)	1.18
30	2531.252	39494.27	$b\ ^3P_2-p\ ^3D^0_1$	7a		0	.515	0/0	.515
80	2530.968	39498.70	$b\ ^3P_1-p\ ^3D^0_2$	1	.32	0	.840	1.48	1.16
3	2530.168	39511.19	$b\ ^3G_4-x\ ^1F^0_3$						

TABLE 1.—*Second spectrum of columbium* (Cb II)—Continued

Intensity spark	λ air A	Wave No. vac. cm⁻¹	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g 1	g 2
1	2	3	4	5	6	7	8	8	10
2	2530.103	39512.21	a $^3P_1$–x $^3G_3^1$ / a $^3G_3$–x $^3D_3^1$						
20	2527.914	39546.42	b $^3P_1$–v $^3D_1^1$	3	0.984	0.982	0.529, 1.515	1.514	0.530
4	2527.277	39556.38	a $^3D_2$–y $^1F_3^1$						
100	2525.806	39579.42	a $^3G_3$–x $^3G_3^1$	7b, 3		0	1.19	(1.180)	1.20
5c	2523.761	39611.49	a $^1P_1$–x $^3P_2^1$						
2h	2522.885	39625.24	a $^1I_6$–w $^3G_5^1$						
8h	2522.341	39633.79	a $^3G_3$–x $^3F_4^1$						
150	2521.404	39648.52	a $^3H_4$–y $^1G_4^1$	3		.48	.88±	.82	.94
2h	2520.663	39660.17	a $^3D_3$–5271						
5	2519.841	39673.11	a $^1D_2$–v $^3F_3^1$						
10c	2519.092	39675.44	b $^3H_4$–x $^1G_4^1$						
10h	2517.487	39710.20	b $^3D_3$–u $^3F_4^1$	7b, 2		0	1.445	(1.312)	1.345
1	2514.500	39757.37	a $^3F_4$–w $^3F_3^1$						
6	2514.352	39759.71	a $^3D_3$–z $^3F_4^1$	1	.23	0		(1.486)	1.26
120	2511.004	39812.72	a $^3P_0$–y $^3P_1^1$	7a		0	1.770	0/0	1.770
5	2505.911	39893.63	a $^3G_4$–x $^3G_5^1$						
3	2504.948	39908.97	b $^3F_3$–5271						
2	2503.431	39933.15	a $^3F_4$–z $^1G_4^1$ / a $^3G_3$–x $^3G_3^1$						
40	2502.496	39948.06	a $^3G_4$–x $^3F_4^1$	3	.17	.68	1.14±	1.05	1.22
10	2500.426	39981.12	a $^3G_4$–x $^3G_4^1$						
20	2498.244	40016.05	b $^3D_3$–u $^1D_2^1$	7b, 3		0	1.32	(1.312)	1.33
4	2496.976	40036.37	b $^3F_4$–w $^3G_4^1$						
3	2496.806	40039.10							
30h	2490.[illegible]7	40145.03	b $^3D_3$–u $^3D_3^1$	7b, 3		0	1.18	(1.171)	1.19
30h	2490.1[illegible]	40146.74							
2	2489.466	40157.14	b $^3D_2$–v $^3G_3^1$						
5	2488.234	40177.02	a $^3F_3$–w $^3F_3^1$						
8	2485.420	40222.51	a $^3D_3$–w $^3G_3^1$						
20	2484.931	40230.42	a $^1G_4$–w $^3G_4^1$	2		0	1.556	(1.083)	1.178
50	2483.878	40247.47	a $^3G_4$–x $^3G_4^1$	3		.44		(1.052)	1.16
15	2483.721	40250.02	a $^3F_3$–w $^3F_3^1$						
60	2479.933	40311.49	a $^3H_4$–x $^3G_4^1$	1		0	1.040	(1.157)	1.18
2	2479.454	40319.28	b $^3F_3$–v $^3D_3^1$						
60	2478.283	40338.33	a $^3G_3$–x $^3G_3^1$	3		w	.79±	(.765)	.815
20	2477.936	40343.98	b $^3F_4$–v $^3D_3^1$						
150	2477.379	40353.05	a $^3P_1$–y $^3P_2^1$	7b, 2		0	1.518	(1.495)	1.506
2h	2474.187	40405.10	b $^3D_3$–v $^3G_4^1$						
20	2472.376	40434.70	b $^3F_3$–v $^3D_3^1$	7b, 1		0	1.140	(1.150)	1.156
20c	2471.318	40452.01	a $^1D_2$–5271						
8	2466.563	40529.98	a $^3D_3$–v $^3D_3^1$	2	.20		1.60	1.00	1.20
4h	2465.199	40552.41							
15h	2464.648	40561.47							
4c	2462.500	40596.85	a $^1P_2$–v $^1F_3^1$						
60	2462.047	40604.32	a $^3G_3$–x $^3G_4^1$						
8c	2461.174	40618.72							
8h	2459.563	40645.32	a $^3D_2$–v $^3D_3^1$						
2	2459.434	40647.46	a $^3D_3$–w $^3G_4^1$						
40	2458.083	40669.80	a $^1G_4$–x $^1F_3^1$	7b, 2		0	1.144	(1.083)	1.063
6c	2456.676	40693.09	a $^3D_3$–v $^3D_3^1$	2	.466	0	1.468	1.002	.536
4h	2454.376	40731.22							
20	2453.945	40738.37	b $^3F_3$–w $^3G_3^1$	1		0	.78	(1.150)	1.06
15	2453.853	40739.90	a $^3H_5$–z $^3F_4^1$						
2	2452.468	40762.90	b $^3F_4$–w $^3G_4^1$						
60	2451.870	40772.85	a $^1D_2$–y $^1F_3^1$	2		0	1.074	(1.003)	1.027
2	2450.900	40788.98	a $^3G_3$–z $^1I_6^1$						
10	2450.433	40796.75	a $^3P_0$–z $^3S_1^1$	7a		0	1.82	0/0	1.82
10	2450.250	40799.79	b $^3P_1$–x $^1F_3^1$						
5	2450.069	40802.81	b $^3D_1$–u $^3D_1^1$	7b, 3		0	.66	(.681)	.64
20c	2448.258	40833.00							
15	2447.906	40837.86	a $^3F_4$–y $^1G_4^1$						

TABLE 1.—*Second spectrum of columbium* (Cb II)—Continued

Intensity spark	λ_{air} Å	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	θ_1	θ_2
1	2	3	4	5	6	7	8	9	10
2	2445.402	40880.68	$a\ ^2P_1-z\ ^2S_{\frac{1}{2}}$						
3h	2444.856	40889.81							
10	2444.479	40896.11	$b\ ^2F_{\frac{7}{2}}-w\ ^2G_{\frac{9}{2}}$	7b, 2		0	0.921	(0.849)	0.872
2	2443.718	40908.85	$a\ ^2D_2-z\ ^2D_{\frac{3}{2}}$						
40	2442.677	40926.28	$b\ ^2G_{\frac{9}{2}}-z\ ^2G_{\frac{7}{2}}$	3		.30	.975±	.950	1.000
40	2442.144	40935.21	$a\ ^2G_{\frac{9}{2}}-y\ ^2D_{\frac{5}{2}}$	1	0.204	0	.353	.761	.958
30	2441.856	40940.04	$a\ ^2P_{\frac{3}{2}}-v\ ^2F_{\frac{5}{2}}$	1	.39	0		(1.063)	1.27
8	2440.976	40954.80	$a\ ^2D_3-v\ ^2D_{\frac{5}{2}}$						
50	2437.411	41014.70	$a\ ^2F_{\frac{7}{2}}-z\ ^2F_{\frac{7}{2}}$	1	.24	0	.47	.71	.86
50	2435.962	41039.26	$a\ ^2H_{\frac{9}{2}}-x\ ^2G_{\frac{9}{2}}$	1		0	.53	(1.050)	1.18
5c	2435.374	41049.00	$a\ ^2P_{\frac{1}{2}}-w\ ^2P_{\frac{3}{2}}$						
10h	2435.074	41054.05	$a\ ^2D_{\frac{3}{2}}-v\ ^2D_{\frac{3}{2}}$						
3	2434.662	41061.00	$b\ ^2P_{\frac{3}{2}}-z\ ^2D_{\frac{5}{2}}$						
2	2434.117	41070.19	$a\ ^2D_3-v\ ^2D_{\frac{3}{2}}$						
60	2433.792	41075.68	$a\ ^2H_{\frac{9}{2}}-z\ ^2G_{\frac{9}{2}}$	7b, 2		0	.850	(.825)	.837
10c	2432.822	41092.05							
10c	2432.321	41100.52	$a\ ^2P_{\frac{1}{2}}-v\ ^2F_{\frac{5}{2}}$						
30c	2431.679	41111.36							
4h	2430.310	41134.52	$a\ ^2P_{\frac{1}{2}}-y\ ^2P_{\frac{1}{2}}$						
8h	2429.603	41163.43							
5h	2426.243	41203.47	$b\ ^2F_{\frac{7}{2}}-v\ ^2D_{\frac{5}{2}}$						
4h	2426.128	41205.42							
5h	2425.112	41222.68							
4h	2423.532	41249.56							
2	2422.976	41259.02	$a\ ^2P_{\frac{3}{2}}-y\ ^2P_{\frac{3}{2}}$						
2	2421.016	41292.42	$a\ ^2F_{\frac{7}{2}}-y\ ^2D_{\frac{5}{2}}$						
10	2419.467	41318.85	$b\ ^2F_{\frac{7}{2}}-v\ ^2D_{\frac{5}{2}}$	3	.32	.63	.84, 1.16	.84	1.16
150	2418.687	41332.18	$a\ ^2G_{\frac{9}{2}}-v\ ^2F_{\frac{7}{2}}$	1		0	.97	(1.052)	1.08
20	2417.323	41355.50	$b\ ^2F_{\frac{7}{2}}-w\ ^2G_{\frac{7}{2}}$	2		0	1.31	(1.152)	1.18
150	2416.994	41361.13	$a\ ^2G_{\frac{7}{2}}-v\ ^2F_{\frac{7}{2}}$	1		0	.88	(1.180)	1.26
2	2416.679	41366.52	$b\ ^2F_{\frac{5}{2}}-z\ ^2D_{\frac{5}{2}}$						
3	2416.247	41373.92	$a\ ^2D_2-w\ ^2G_{\frac{7}{2}}$						
30	2416.169	41375.25	$a\ ^2P_{\frac{3}{2}}-527\frac{1}{2}$	3	1.26	.77	1.42, .68	1.68	1.42
10c	2415.955	41378.91	$a\ ^2P_{\frac{3}{2}}-w\ ^2P_{\frac{3}{2}}$						
150	2412.460	41438.86	$a\ ^2F_{\frac{5}{2}}-z\ ^2D_{\frac{5}{2}}$						
5h	2412.283	41441.90							
5h	2411.235	41459.91							
20c	2410.285	41476.25	$a\ ^2P_{\frac{1}{2}}-w\ ^2P_{\frac{1}{2}}$	7a		0	2.47	2.47	0.0
6	2410.080	41479.77							
20h	2407.685	41521.03	$a\ ^2H_{\frac{9}{2}}-z\ ^2H_{\frac{9}{2}}$						
60c	2405.850	41552.70	$a\ ^2P_{\frac{3}{2}}-w\ ^2P_{\frac{3}{2}}$	3	.375	.75	1.44, 1.81	1.815	1.440
50c	2405.344	41561.44	$a\ ^2P_{\frac{1}{2}}-w\ ^2P_{\frac{3}{2}}$	3	1.045	1.041	1.49, 2.48	2.475	1.490
20	2404.210	41581.04							
8h	2402.658	41607.90							
4	2401.272	41631.91							
4	2401.040	41635.93	$a\ ^2F_{\frac{5}{2}}-495\frac{1}{2}$						
2	2398.768	41675.36	$a\ ^2G_{\frac{7}{2}}-v\ ^2F_{\frac{7}{2}}$						
120	2398.484	41680.30	$a\ ^2G_{\frac{9}{2}}-v\ ^2F_{\frac{9}{2}}$	1		0	.72	(.765)	.79
6	2397.967	41689.29	$a\ ^2G_{\frac{7}{2}}-v\ ^2F_{\frac{7}{2}}$						
2	2397.677	41694.33	$a\ ^2D_{\frac{3}{2}}-y\ ^2D_{\frac{3}{2}}$						
4c	2397.558	41696.40	$a\ ^2P_{\frac{3}{2}}-y\ ^2P_{\frac{3}{2}}$						
2	2396.772	41710.07	$a\ ^2F_{\frac{7}{2}}-z\ ^2P_{\frac{3}{2}}$						
3c	2396.310	41718.11	$a\ ^2P_{\frac{3}{2}}-y\ ^2S_{\frac{1}{2}}$						
8h	2395.824	41726.58							
40	2395.329	41735.20	$a\ ^2P_{\frac{1}{2}}-w\ ^2P_{\frac{1}{2}}$	1	1.03	0	.41	2.47	1.44
2	2394.697	41746.21	$a\ ^2D_{\frac{3}{2}}-v\ ^2D_{\frac{3}{2}}$						
20	2391.912	41794.81	$b\ ^2F_{\frac{5}{2}}-z\ ^2F_{\frac{5}{2}}$						
3h	2390.718	41815.69							
40	2388.269	41858.56	$a\ ^2F_{\frac{7}{2}}-z\ ^2D_{\frac{7}{2}}$	3	.22	.67	1.18±	1.07	1.20
80	2387.521	41871.67	$a\ ^2F_{\frac{7}{2}}-w\ ^2D_{\frac{7}{2}}$	1		0	.88	(1.070)	1.150
80	2387.101	41879.04	$a\ ^2P_{\frac{3}{2}}-527\frac{1}{2}$	1	.40	0	.61	1.81	1.41
10h	2385.251	41911.52							
5h	2384.852	41918.52							
3	2381.717	41973.80	$a\ ^2D_{\frac{3}{2}}-y\ ^2D_{\frac{3}{2}}$						
2	2381.122	41984.19	$a\ ^2P_{\frac{3}{2}}-z\ ^2D_{\frac{3}{2}}$						

TABLE 1.—*Second spectrum of columbium* (Cb II)—Continued

Intensity spark	λ air Å	Wave No. vac. cm⁻¹	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
10h	2380.148	42001.37							
5h	2379.122	42019.48							
4	2378.476	42030.89	$a\ ^3F_3-495\frac{1}{2}$						
10	2377.989	42039.50	$b\ ^3H_4-p\ ^3G\frac{1}{2}$						
100	2376.308	42067.64	$a\ ^3D_3-z\ ^3H\frac{1}{2}$						
8	2374.167	42107.16	$b\ ^3H_3-u\ ^3F\frac{1}{2}$						
10c	2373.967	42110.71	$a\ ^3G_4-527\frac{1}{2}$						
60	2372.730	42132.66	$a\ ^3D_3-y\ ^3D\frac{1}{2}$						
8c	2372.227	42141.60	$a\ ^3G_3-w\ ^3P\frac{1}{2}$						
100	2369.954	42182.01	$a\ ^3F_3-z\ ^3D\frac{1}{2}$	1		0	0.63	(0.712)	0.81
8c	2368.941	42200.05	$a\ ^3P_2-y\ ^1F\frac{1}{2}$						
20h	2366.198	42248.96							
10h	2365.745	42257.05	$b\ ^3G_3-u\ ^3F\frac{1}{2}$						
20h	2365.624	42259.21							
2h	2365.305	42264.91	$a\ ^3F_4-z\ ^1G\frac{1}{2}$						
70	2365.215	42266.52	$a\ ^3F_3-w\ ^3D\frac{1}{2}$	3	0.46	.93	.70, 1.16	.70	1.16
2h	2364.270	42283.41	$b\ ^1G_4-u\ ^1F\frac{1}{2}$						
3	2363.587	42295.63	$a\ ^3F_2-z\ ^3P\frac{1}{2}$						
60	2360.302	42354.49	$a\ ^1G_4-z\ ^1G\frac{1}{2}$	3		.27	1.05±	1.09	1.01
3	2357.437	42405.96	$a\ ^3D_3-z\ ^1F\frac{1}{2}$						
20	2356.290	42426.60	$a\ ^3P_2-z\ ^3D\frac{1}{2}$, $a\ ^3H_4-p\ ^3F\frac{1}{2}$						
40	2356.005	42431.73	$a\ ^3G_4-y\ ^1F\frac{1}{2}$	70, 2		0	1.07	(1.052)	1.04
6	2355.680	42437.59	$a\ ^1D_2-y\ ^1D\frac{1}{2}$						
20	2354.040	42467.15	$a\ ^3H_5-o\ ^3F\frac{1}{2}$						
3	2353.765	42472.11	$a\ ^3P_1-w\ ^3D\frac{1}{2}$						
60	2352.837	42488.86	$a\ ^1D_2-y\ ^3D\frac{1}{2}$						
60	2352.338	42497.87	$a\ ^3P_2-z\ ^3D\frac{1}{2}$						
4	2351.613	42510.98	$a\ ^3P_2-w\ ^3D\frac{1}{2}$						
20h	2350.488	42531.32	$a\ ^3F_4-z\ ^3G\frac{1}{2}$						
5h	2349.411	42550.81							
2	2347.111	42592.50	$a\ ^3F_3-y\ ^3G\frac{1}{2}$						
3	2346.961	42595.22							
50	2346.532	42603.01	$a\ ^3P_2-w\ ^3D\frac{1}{2}$	1		0	1.10	(1.450)	1.33
15h	2345.333	42624.79	$b\ ^3H_4-o\ ^3G\frac{1}{2}$						
10	2343.271	42662.30	$a\ ^3D_4-y\ ^3D\frac{1}{2}$						
2h	2343.103	42665.36							
4h	2342.852	42669.93	$a\ ^5P_3-o\ ^3D\frac{1}{2}$						
20h	2340.025	42721.47							
10	2335.620	42802.04	$b\ ^3H_3-o\ ^3G\frac{1}{2}$						
20	2335.322	42807.68	$a\ ^3P_2-500\frac{1}{2}$						
100	2334.802	42817.03	$a\ ^3D_3-y\ ^3D\frac{1}{2}$						
10	2332.896	42852.01	$a\ ^3D_2-y\ ^3D\frac{1}{2}$						
2h	2332.295	42863.05							
4	2328.028	42941.61	$a\ ^3F_2-z\ ^3P\frac{1}{2}$						
2h	2327.521	42950.96	$a\ ^3F_3-z\ ^3G\frac{1}{2}$						
10	2327.131	42958.16	$a\ ^3P_0-y\ ^1P\frac{1}{2}$						
20	2326.221	42974.96	$a\ ^3H_5-y\ ^1HI\frac{1}{2}$						
4h	2325.504	42988.21							
3h	2324.409	43008.46							
60	2324.237	43011.75	$a\ ^5D_3-z\ ^5P\frac{1}{2}$	1	.75	0	.75	1.50	2.25
40	2324.063	43014.86	$b\ ^3H_6-o\ ^3G\frac{1}{2}$						
10h	2323.512	43025.06							
20	2321.996	43053.15	$a\ ^3P_1-z\ ^3D\frac{1}{2}$						
2h	2321.271	43066.60							
7h	2320.659	43077.95							
25	2320.238	43085.75	$a\ ^5D_3-y\ ^5D\frac{1}{2}$						
5	2319.847	43093.03							
25	2319.589	43097.82	$a\ ^3G_4-w\ ^3G\frac{1}{2}$						
3h	2318.180	43124.01							
10	2317.784	43131.38	$a\ ^5D_1-y\ ^5D\frac{1}{2}$						

TABLE 1.—*Second spectrum of columbium* (Cb II)—Continued

Intensity spark	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	8	10
1Å	2316.929	43147.49	$\left\{\begin{matrix}b\ ^3H_3-v\ ^3G^0_4\\ b\ ^3P_2-u\ ^3F^0_3\end{matrix}\right.$						
30	2315.173	43180.02	$a\ ^5D_2-y\ ^5D^0_1$						
50	2314.850	43186.04	$a\ ^3P_2-x\ ^3P^0_2$	3		0.20	1.41±	1.46	1.36
3	2314.240	43197.43	$a\ ^1D_2-x\ ^1F^0_3$						
15	2313.524	43210.79	$a\ ^5D_3-y\ ^5D^0_2$						
20Å	2311.456	43249.45							
2	2310.570	43266.03	$a\ ^3F_3-y\ ^3F^0_4$						
8	2310.313	43270.84							
3	2309.742	43281.54	$a\ ^3F_3-y\ ^1D^0_2$						
100	2309.239	43290.97	$a\ ^5D_1-z\ ^5P^0_1$	3	0.76	.76	1.50, 2.26	1.50	2.26
6	2308.807	43299.07	$a\ ^3F_1-y\ ^3F^0_2$						
3	2307.477	43324.02	$a\ ^3P_2-x\ ^3G^0_3$						
4Å	2305.426	43362.56							
4	2303.154	43405.33	$a\ ^5G_4-v\ ^5D^0_3$						
40	2302.695	43413.98	$a\ ^5D_4-y\ ^5D^0_3$						
200	2302.086	43425.47	$a\ ^5D_3-z\ ^5P^0_2$	1	.25	0	1.00	1.50	1.75
50	2300.785	43450.02	$a\ ^5D_0-z\ ^5P^0_1$	7a		0	2.255	0/0	2.25
5	2300.519	43455.04	$\left\{\begin{matrix}a\ ^5G_2-w\ ^5G^0_3\\ b\ ^3F_3-x\ ^1G^0_4\end{matrix}\right.$						
30	2300.339	43458.44	$a\ ^1D_2-x\ ^1D^0_2$	7b		0	1.002	1.002	1.00
20	2299.226	43479.48	$b\ ^3F_4-x\ ^1G^0_4$						
5	2298.662	43490.14	$a\ ^5D_1-y\ ^5D^0_0$						
10	2298.385	43495.38	$a\ ^1P_1-x\ ^3D^0_1$						
40Å	2297.853	43505.45							
50	2297.611	43510.04	$a\ ^5G_2-w\ ^5G^0_2$						
3	2296.748	43526.38	$a\ ^3H_4-y\ ^3F^0_3$						
8	2295.972	43541.10	$a\ ^3P_1-w\ ^3D^0_2$						
300	2295.681	43546.61	$a\ ^5D_4-z\ ^5P^0_3$						
60	2294.983	43559.85	$b\ ^5G_4-v\ ^5G^0_3$						
40	2293.926	43579.93	$a\ ^3P_1-w\ ^3D^0_1$						
8Å	2292.325	43610.36							
20Å	2291.644	43623.32							
8	2291.383	43628.29	$a\ ^5D_2-z\ ^5P^0_3$						
6	2290.289	43649.12	$a\ ^5D_0-y\ ^5D^0_1$						
30	2288.861	43676.35	$a\ ^3F_3-y\ ^1D^0_2$						
7	2286.892	43713.95	$a\ ^3F_3-z\ ^3F^0_4$						
20	2286.749	43716.69							
10Å	2286.352	43724.28							
5Å	2285.673	43737.26							
60	2285.223	43745.88	$a\ ^5D_4-y\ ^5D^0_4$	7b, 3		0	1.490	(1.495)	1.48
10	2284.356	43762.47	$a\ ^5G_3-v\ ^5D^0_4$						
300	2283.004	43788.39	$a\ ^5D_3-z\ ^5P^0_3$	3	.25	.50	1.49, 1.74	1.49	1.74
80Å	2281.830	43810.92							
30	2281.136	43824.25	$a\ ^5G_4-w\ ^5G^0_4$						
50	2280.450	43837.43	$a\ ^5D_3-y\ ^5D^0_3$						
4Å	2278.477	43875.38	$b\ ^1G_4-v\ ^3G^0_4$						
4Å	2278.320	43878.41							
3	2276.361	43916.16	$a\ ^3F_3-y\ ^3F^0_3$						
6	2276.170	43919.85	$a\ ^3F_3-z\ ^3F^0_4$						
60	2274.198	43957.93	$b\ ^3G_3-v\ ^3G^0_4$						
100	2274.128	43959.28	$a\ ^3F_4-v\ ^3F^0_4$	7b, 3		w	1.246	(1.230)	1.20
150	2273.566	43970.15	$a\ ^5D_3-z\ ^5P^0_2$	3		.25	1.52±	1.48	1.56
6Å	2273.120	43978.77							
100	2272.730	43986.32	$a\ ^3F_4-z\ ^3F^0_4$						
2	2270.65	44026.6	$a\ ^3F_3-v\ ^3F^0_3$						
150	2270.180	44035.72	$a\ ^3F_3-v\ ^3F^0_4$	7b		0	1.07	1.07	1.07
100	2269.865	44041.83	$b\ ^3G_3-v\ ^3G^0_3$						
10Å	2269.202	44054.70							
150	2268.527	44067.81	$a\ ^1D_2-z\ ^1P^0_1$						
100	2266.732	44102.70	$a\ ^5G_3-w\ ^5G^0_3$						
100	2265.676	44123.26	$a\ ^5D_3-z\ ^5P^0_3$						

TABLE 1.—*Second spectrum of columbium* (Cb II)—Continued

Intensity spark	λ air A	Wave No. vac. cm⁻¹	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
150	2264.556	44145.07	$b\ ^3G_4 - p\ ^3G^0_4$						
3h	2264.09	44154.2	$b\ ^3G_3 - u\ ^3D^0_3$						
15	2263.312	44169.34	$a\ ^3D_3 - y\ ^3D^0_3$						
15	2263.219	44171.15	$a\ ^3P_2 - w\ ^3D^0_2$						
2	2262.34	44188.3	$a\ ^3F_4 - y\ ^3F^0_4$						
10	2262.132	44192.38	$a\ ^3H_4 - w\ ^3G^0_4$						
5	2261.721	44200.40	$a\ ^3D_3 - y\ ^3D^0_3$						
20h	2261.531	44204.12							
60	2257.537	44282.32	$a\ ^3P_1 - z\ ^3P^0_1$						
200	2255.597	44320.40	$a\ ^3F_3 - z\ ^3F^0_3$						
4	2255.175	44328.69	$a\ ^3D_3 - u\ ^3F^0_4$						
60	2254.953	44333.05	$a\ ^3D_3 - z\ ^3P^0_2$						
20	2252.623	44378.90	$a\ ^3F_3 - v\ ^3F^0_4$						
250	2252.210	44387.04	$b\ ^3G_3 - v\ ^3G^0_4$	7b		0	1.19	1.19	1.19
100h	2250.463	44421.49	$a\ ^3F_3 - v\ ^3F^0_3$						
8h	2250.005	44430.54	$a\ ^3F_2 - v\ ^3F^0_1$						
60	2248.282	44464.60							
4	2247.188	44486.22	$a\ ^3D_2 - z\ ^3P^0_1$						
20h	2246.98	44490.35	$b\ ^3G_4 - p\ ^3G^0_3$						
20h	2246.500	44499.85	$a\ ^3H_4 - v\ ^3D^0_3$						
2	2245.15	44526.6	$a\ ^3P_2 - y\ ^1P^0_1$						
10	2242.58	44577.6	$a\ ^3D_4 - z\ ^1F^0_3$						
20h	2241.011	44608.83	$a\ ^1G_4 - u\ ^3F^0_3$						
20h	2240.65	44616.0	$a\ ^3H_4 - w\ ^3G^0_3$						
2	2238.14	44666.0	$a\ ^3F_3 - v\ ^3F^0_2$						
2	2237.69	44675.0	$a\ ^3F_2 - v\ ^3F^0_2$						
20	2237.496	44678.90							
6h	2236.95	44689.8	$a\ ^3D_1 - u\ ^3F^0_2$						
60	2236.724	44694.32	$a\ ^3D_4 - y\ ^3G^0_4$						
4h	2236.43	44700.2							
2	2235.89	44711.0	$a\ ^3F_4 - z\ ^1G^0_4$						
2	2235.66	44715.6	$a\ ^3F_4 - y\ ^1F^0_3$						
10	2230.85	44812.0	$b\ ^3F_3 - u\ ^3F^0_3$						
4	2230.74	44814.2	$a\ ^3F_3 - 5275$						
2	2230.44	44820.2	$a\ ^3D_3 - y\ ^3G^0_3$						
150h	2229.716	44834.78	$a\ ^3H_4 - w\ ^3G^0_3$	7b, 1		0	1.007	(1.157)	1.157
30h	2228.986	44849.46							
6h	2225.547	44918.76	$a\ ^3H_4 - w\ ^3G^0_4$						
20	2224.667	44936.53	$a\ ^3D_3 - y\ ^3P^0_2$						
5	2221.415	45002.30	$b\ ^3F_3 - u\ ^3F^0_4$						
10	2219.328	45044.62	$b\ ^3P_2 - u\ ^3D^0_3$						
5	2219.163	45047.97	$a\ ^3F_3 - w\ ^3F^0_4$						
4	2215.29	45126.7	$a\ ^3F_3 - w\ ^3F^0_3$						
2	2214.87	45135.3	$a\ ^3F_3 - y\ ^1F^0_3$						
7	2211.274	45208.66	$a\ ^3H_3 - w\ ^3G^0_3$						
20	2210.917	45215.97	$a\ ^3D_3 - y\ ^3P^0_1$						
10	2210.534	45223.80	$a\ ^3F_3 - z\ ^1G^0_4$						
20	2207.182	45292.47	$a\ ^3F_3 - y\ ^3S^0_1$						
5h	2206.639	45303.61	$a\ ^1G_4 - v\ ^3G^0_3$						
100h	2203.64	45365.3							
6	2203.17	45374.9	$a\ ^3D_3 - y\ ^3P^0_2$						
1	2202.86	45381.3	$a\ ^3F_4 - w\ ^3G^0_4$						
7	2202.01	45398.8	$a\ ^3F_3 - w\ ^3F^0_3$						
6h	2201.36	45412.2							
60h	2199.97	45440.9							
8	2199.60	45448.6	$a\ ^3F_3 - w\ ^3F^0_2$						
20h	2196.40	45514.8							
7	2192.41	45597.6	$a\ ^3F_3 - w\ ^3F^0_4$						
5	2188.14	45686.6							
1	2187.66	45696.6	$b\ ^3F_3 - u\ ^3F^0_2$						
5	2187.03	45709.8	$b\ ^3F_3 - u\ ^3F^0_3$						
3	2185.87	45734.0	$b\ ^3F_4 - u\ ^3F^0_4$						
4	2185.41	45743.7	$a\ ^3D_3 - y\ ^3P^0_3$						
10	2180.67	45843.1	$b\ ^3F_4 - v\ ^3G^0_4$						
30	2176.76	45925.4							

TABLE 1.—*Second spectrum of columbium* (Cb II)—Continued

Intensity spark	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	θ_1	θ_2
1	2	3	4	5	6	7	8	9	10
40	2175.84	45944.8	a $^3D_2$—u $^3D_3^0$						
4	2172.41	46017.3							
5	2170.72	46053.2							
10	2169.89	46070.8	a $^3D_3$—y $^3P_2^0$						
3	2168.18	46107.1							
50	2167.24	46127.1							
3	2163.84	46199.6							
6	2163.07	46216.0	a $^3F_3$—z $^3D_3^0$						
2	2162.63	46225.4	a $^1P_1$—y $^1P_1^0$						
40	2160.34	46274.4							
100	2160.27	46275.9							
15	2158.14	46321.6	a $^3F_4$—w $^3D_3^0$						
30	2156.74	46351.7	a $^3F_3$—z $^3G_3^0$						
40	2155.62	46375.7							
2	2155.14	46386.1	a $^3D_1$—y $^3P_2^0$						
7	2154.47	46400.5							
10	2154.20	46406.3	a $^3F_3$—z $^3F_3^0$						
3	2153.30	46425.7							
4	2152.06	46452.4							
40	2149.54	46506.9	a $^3F_3$—4951						
5	2149.03	46517.9							
15	2148.65	46526.1	a $^3F_4$—5001						
30	2147.20	46557.6							
3	2144.79	46609.9							
2	2144.49	46616.4	a $^3F_3$—x $^3D_3^0$						
4	2143.20	46644.4							
5	2142.91	46650.8	a $^3D_3$—u $^3D_3^0$						
5	2142.02	46670.1							
3	2141.06	46691.1	b $^3F_3$—u $^3D_3^0$						
2	2140.48	46703.7	b $^3F_3$—o $^3G_3^0$						
10	2140.39	46705.7	a $^3F_4$—z $^3G_3^0$						
10	2138.90	46738.2							
5	2138.42	46748.7	a $^3P_2$—o $^3D_3^0$						
40	2137.55	46767.7							
30	2137.05	46778.7							
25	2134.95	46824.7							
30	2134.71	46829.9							
20	2134.49	46834.8	a $^3F_3$—w $^3D_3^0$						
4	2133.67	46852.8	a $^3D_1$—w $^3F_3^0$						
2	2133.17	46863.7	a $^3P_1$—o $^3D_3^0$						
8	2132.83	46871.2							
1	2132.02	46889.0	a $^3F_1$—x $^3D_3^0$						
60	2131.18	46907.5	a $^3F_3$—4951						
3	2129.00	46955.5	a $^3F_4$—z $^3G_3^0$						
2	2128.21	46972.9	a $^3P_2$—u $^3F_3^0$						
60	2126.54	47009.8	a $^3F_4$—z $^3F_3^0$						
60	2125.21	47039.2	a $^3F_3$—5001						
6	2124.34	47058.5	a $^3F_3$—x $^3D_3^0$						
7	2120.52	47143.3	a $^3F_3$—w $^3D_3^0$						
3	2119.99	47155.1	a $^3P_1$—u $^3F_3^0$						
4	2119.63	47163.1	a $^3P_2$—u $^3F_3^0$						
6	2119.06	47175.7							
20	2118.87	47180.0	a $^3F_3$—4951						
10	2116.39	47235.3	a $^3F_3$—w $^3D_3^0$						
5	2114.77	47271.4							
50	2113.08	47309.2	a $^3F_4$—z $^3G_3^0$						
10	2110.04	47377.4							
150	2109.43	47391.1							
2	2108.34	47415.6	a $^3F_4$—w $^3D_3^0$						
2	2108.23	47418.1	a $^3F_3$—z $^3P_2^0$						
40	2107.27	47439.7	a $^3F_3$—5001						
20	2103.59	47522.6	a $^3F_3$—z $^3F_3^0$						
5	2102.12	47555.9	a $^3F_3$—z $^3G_3^0$						
3	2101.87	47561.5	a $^3F_3$—z $^1I_6^0$						
7	2099.48	47615.7							

TABLE 1.—*Second spectrum of columbium* (Cb II)—Continued

Intensity spark	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest u	g_1	g_2
1	2	3	4	5	6	7	8	9	10
15	2098.05	47648.1							
5	2097.23	47666.7	$a\ ^5P_3-u\ ^5F_4^1$						
10	2094.95	47718.6							
20	2090.41	47822.2	$a\ ^5F_2-x\ ^5G_3^1$						
2	2089.36	47846.3	$a\ ^5F_3-x\ ^5P_2^1$						
1	2085.56	47933.4	$a\ ^5D_4-y\ ^1G_4^1$						
10	2085.37	47937.8	$a\ ^5F_1-x\ ^5P_2^1$						
15	2084.30	47962.4							
1	2083.51	47980.6	$a\ ^5P_1-p\ ^5D_0^1$						
3	2082.89	47994.9							
0	2081.37	48029.9							
5	2080.33	48053.9	$a\ ^5P_3-u\ ^5F_3^1$						
10	2080.05	48060.4							
15	2079.71	48068.2							
20	2076.88	48133.7	$a\ ^5F_3-p\ ^5F_3^1$						
4	2074.32	48193.1							
2	2073.33	48216.1	$a\ ^5F_2-x\ ^1D_2^1$						
5	2072.07	48245.5							
10	2065.71	48394.0	$a\ ^5F_4-p\ ^5F_3^1$						
15	2064.71	48429.1							
2	2061.97	48481.7	$a\ ^5G_4-u\ ^5F_4^1$						
15	2061.45	48494.0							
20	2057.05	48597.7							
4	2054.19	48665.3							
5	2051.16	48737.2	$a\ ^5F_4-p\ ^5F_4^1$						
10	2050.93	48742.7							
10	2049.89	48767.4							
1	2048.70	48795.7	$a\ ^5G_4-u\ ^5F_5^1$						
1	2047.44	48825.7	$a\ ^5F_1-y\ ^1D_2^1$						
1	2044.41	48898.1	$a\ ^5F_2-p\ ^5F_1^1$						
5	2044.22	48902.6							
1	2044.02	48907.4	$a\ ^5F_2-p\ ^5F_2^1$						
4	2043.53	48919.2							
4	2043.18	48927.5							
10	2037.96	49053.1							
20	2032.99	49172.7	$a\ ^5F_4-527_5^1$						
10	2029.33	49261.4							
10	2025.31	49359.2	$a\ ^5F_3-w\ ^5F_3^1$						
3	2019.79	49494.1	$a\ ^5F_4-y\ ^1F_3^1$						
3	2018.67	49521.5	$a\ ^5G_4-p\ ^5G_4^1$						
5	2017.28	49555.6							
1	2016.67	49570.6	$a\ ^5F_1-p\ ^5F_2^1$						
10	2016.05	49585.9	$a\ ^5F_2-w\ ^5F_1^1$						
3	2015.69	49594.7							
6	2011.99	49685.9	$a\ ^5F_3-527_5^1$						
7	2008.99	49760.1							
7	2008.46	49773.2	$a\ ^5F_1-w\ ^5F_2^1$						
5	2005.02	49858.6							
4	2004.76	49865.1							
3	2002.41	49923.6							

2. TERMS OF THE CB II SPECTRUM

The established terms (atomic energy states) of the Cb II spectrum are described in table 2, in which successive columns show (1) the electron configuration responsible for the term, (2) term symbols, (3) level values, (4) level separations in polyfold terms, (5) g-values derived from the Zeeman effect, and (6) observed combinations. All level values are relative to $(4d^4)\ a\ ^5D_0=0.00$. The total number of levels is 183, of which 27 represent singlet terms, 116 comprise 40 triplet terms, 37 belong to 9 quintet terms, and 3 are fragments of

$d^2\,sp$ terms. Negative signs in column 4 show that 2 polyfold terms are inverted and 14 partially inverted. The remainder are regular but many violations of the rule that intervals are proportional to the larger j-values occur. Of special interest is the term $z\,^5D^\circ$, whose fourth interval is abnormally small. Attention was called to the same abnormality in the analogous V II spectrum [7]. The term $y\,^5D^\circ$ is also extremely irregular in both cases.

TABLE 2.—*Terms of the* Cb II *spectrum*

Electron configuration	Term symbol	Level	Difference	Observed g	Combinations
1	2	3	4	5	6
d^4	$a\,^5D_0$	0.00		0/0	
	$a\,^5D_1$	188.99	188.99	1.500	$z\,^3P^\circ$, $z\,^5D^\circ$, $y\,^3D^\circ$, $z\,^3F^\circ$, $z\,^3G^\circ$, $z\,^1P^\circ$, $y\,^3P^\circ$, $z\,^1D^\circ$,
	$a\,^5D_2$	438.38	279.39	1.490	$y\,^1D^\circ$, $z\,^1F^\circ$, $x\,^3F^\circ$, $w\,^3F^\circ$, $z\,^1G^\circ$, $y\,^3G^\circ$, $z\,^1H^\circ$,
	$a\,^5D_3$	801.38	363.00	1.486	$y\,^1H^\circ$, $z\,^1F^\circ$, $z\,^1G^\circ$, $y\,^1G^\circ$.
	$a\,^5D_4$	1224.87	423.49	1.495	
$d^3\,s$	$a\,^5F_1$	2250.76	272.31	0.000	$z\,^3D^\circ$, $z\,^3F^\circ$, $z\,^3G^\circ$, $z\,^3P^\circ$, $y\,^3P^\circ$, $x\,^3P^\circ$, $w\,^3P^\circ$, $z\,^1D^\circ$,
	$a\,^5F_2$	2629.07	400.50	.996	$y\,^3D^\circ$, $x\,^3D^\circ$, $w\,^3D^\circ$, $u\,^3D^\circ$, $z\,^1P^\circ$, $y\,^3F^\circ$, $z\,^1F^\circ$,
	$a\,^5F_3$	3029.57	512.93	1.248	$w\,^1F^\circ$, $u\,^3F^\circ$, $z\,^1G^\circ$, $y\,^3G^\circ$, $x\,^3G^\circ$, $w\,^3G^\circ$, $y\,^1D^\circ$,
	$a\,^5F_4$	3542.50	603.50	1.350	$y\,^1F^\circ$, $z\,^1G^\circ$, $z\,^1I^\circ$, 495°, 500°, 527°.
	$a\,^5F_5$	4146.00		1.390	
d^4	$a\,^3P_0$	5562.26	630.07	0/0	$z\,^3S^\circ$, $z\,^3P^\circ$, $z\,^1D^\circ$, $y\,^3D^\circ$, $z\,^1F^\circ$, $z\,^3S^\circ$, $y\,^3S^\circ$, $z\,^1P^\circ$,
	$a\,^3P_1$	6192.33	1069.00	1.495	$y\,^1P^\circ$, $x\,^3P^\circ$, $z\,^1D^\circ$, $y\,^1D^\circ$, $x\,^1D^\circ$, $w\,^1D^\circ$, $u\,^1D^\circ$,
	$a\,^3P_2$	7261.33		1.450	$z\,^3F^\circ$, $u\,^1F^\circ$, $z\,^1G^\circ$, $x\,^1G^\circ$, $z\,^1P^\circ$, $y\,^1P^\circ$, 500°.
$d^3\,s$	$a\,^3F_2$	7505.78	394.87	.712	$z\,^3P^\circ$, $z\,^3D^\circ$, $y\,^3D^\circ$, $z\,^3F^\circ$, $z\,^3G^\circ$, $z\,^3S^\circ$, $y\,^3S^\circ$, $z\,^1P^\circ$,
	$a\,^3F_3$	7900.65	419.75	1.070	$y\,^3P^\circ$, $x\,^3P^\circ$, $z\,^1D^\circ$, $y\,^1D^\circ$, $x\,^1D^\circ$, $w\,^1D^\circ$, $u\,^1D^\circ$,
	$a\,^3F_4$	8320.40		1.230	$x\,^3F^\circ$, $y\,^1F^\circ$, $x\,^1F^\circ$, $w\,^1F^\circ$, $u\,^1F^\circ$, $z\,^1G^\circ$, $y\,^1G^\circ$, $x\,^1G^\circ$,
					$w\,^1G^\circ$, $u\,^1G^\circ$, $y\,^1H^\circ$, $z\,^1P^\circ$, $z\,^1D^\circ$, $y\,^1D^\circ$, $z\,^1D^\circ$,
					$z\,^1F^\circ$, $y\,^1F^\circ$, $y\,^1G^\circ$, 495°, 527°.
d^4	$a\,^3H_4$	9509.67	302.89	.825	$z\,^1D^\circ$, $z\,^3F^\circ$, $z\,^3G^\circ$, $z\,^3D^\circ$, $y\,^3D^\circ$, $y\,^1D^\circ$, $x\,^1D^\circ$, $z\,^1F^\circ$,
	$a\,^3H_5$	9812.56	373.85	1.050	$y\,^3F^\circ$, $z\,^1F^\circ$, $w\,^1F^\circ$, $y\,^1F^\circ$, $z\,^1G^\circ$, $y\,^1G^\circ$, $x\,^1G^\circ$, $w\,^1G^\circ$,
	$a\,^3H_6$	10186.41		1.157	$u\,^1G^\circ$, $z\,^1H^b$, $y\,^1H^b$, $z\,^1I^\circ$, $z\,^1F^\circ$, $y\,^1F^\circ$, $z\,^1G^\circ$, $y\,^1G^\circ$,
					$z\,^1I^\circ$.
d^4	$a\,^3G_3$	10247.04	357.24	.765	$z\,^1P^\circ$, $z\,^1D^\circ$, $z\,^1F^\circ$, $z\,^1G^\circ$, $w\,^1P^\circ$, $z\,^3D^\circ$, $y\,^1D^\circ$, $z\,^1D^\circ$,
	$a\,^3G_4$	10604.28	314.24	1.052	$w\,^1D^\circ$, $y\,^1D^\circ$, $z\,^1F^\circ$, $y\,^1F^\circ$, $x\,^1F^\circ$, $w\,^1F^\circ$, $z\,^1F^\circ$, $u\,^1F^\circ$,
	$a\,^3G_5$	10918.52		1.180	$z\,^1G^\circ$, $y\,^1G^\circ$, $z\,^1G^\circ$, $w\,^1G^\circ$, $u\,^1G^\circ$, $z\,^1H^\circ$, $y\,^1H^\circ$,
					$z\,^1I^\circ$, $z\,^1D^\circ$, $y\,^1D^\circ$, $z\,^1F^\circ$, $y\,^1F^\circ$, $z\,^1G^\circ$, $y\,^1G^\circ$, $z\,^1H^\circ$,
					$z\,^1I^\circ$, 527°.
$d^3\,s$	$a\,^3P_1$	10653.40	182.45	2.477	$z\,^3S^\circ$, $z\,^3P^\circ$, $z\,^3D^\circ$, $y\,^3D^\circ$, $y\,^3S^\circ$, $z\,^3P^\circ$, $y\,^3P^\circ$, $z\,^1P^\circ$,
	$a\,^3P_2$	10835.85	503.71	1.815	$w\,^3P^\circ$, $x\,^3D^\circ$, $y\,^3D^\circ$, $z\,^3D^\circ$, $w\,^3D^\circ$, $y\,^3D^\circ$, $z\,^3P^\circ$,
	$a\,^3P_3$	11339.56		1.663	$y\,^3F^\circ$, $z\,^1F^\circ$, $w\,^1F^\circ$, $y\,^1F^\circ$, $u\,^1F^\circ$, $y\,^1G^\circ$, $z\,^1G^\circ$, $z\,^1S^\circ$,
					$y\,^1P^\circ$, $z\,^1F^\circ$, $y\,^1F^\circ$, 527°.
d^4	$a\,^1D_2$	12263.26		1.003	$z\,^3S^\circ$, $z\,^3P^\circ$, $y\,^1D^\circ$, $z\,^3P^\circ$, $y\,^3P^\circ$, $x\,^3P^\circ$, $y\,^1D^\circ$, $z\,^1D^\circ$,
					$w\,^1D^\circ$, $y\,^3D^\circ$, $z\,^1F^\circ$, $y\,^1F^\circ$, $z\,^3F^\circ$, $y\,^3F^\circ$, $y\,^1G^\circ$, $z\,^1G^\circ$,
					$z\,^1P^\circ$, $y\,^1P^\circ$, $z\,^1D^\circ$, $y\,^1D^\circ$, $x\,^1D^\circ$, $z\,^1F^\circ$, $y\,^1F^\circ$, $z\,^1I^\circ$,
					527°.
d^4	$b\,^3F_2$	12805.98	884.22	.849	$z\,^1D^\circ$, $y\,^1D^\circ$, $z\,^1F^\circ$, $z\,^1G^\circ$, $z\,^1S^\circ$, $z\,^1P^\circ$, $y\,^1P^\circ$, $z\,^1P^\circ$, $\phi p\,(^1F)$
	$b\,^3F_3$	13690.20	−24.52	1.150	$z\,^1D^\circ$, $y\,^1D^\circ$, $x\,^1D^\circ$, $w\,^1D^\circ$, $v\,^1D^\circ$, $u\,^1D^\circ$, $z\,^1F^\circ$,
	$b\,^3F_4$	13665.68		1.162	$y\,^1F^\circ$, $w\,^1F^\circ$, $v\,^1F^\circ$, $u\,^1F^\circ$, $z\,^1G^\circ$, $y\,^1G^\circ$, $z\,^1G^\circ$,
					$w\,^1G^\circ$, $u\,^1G^\circ$, $z\,^1H^\circ$, $y\,^1H^\circ$, $z\,^1P^\circ$, $y\,^1P^\circ$, $z\,^1D^\circ$,
					$y\,^1D^\circ$, $z\,^1F^\circ$, $y\,^1F^\circ$, $x\,^1F^\circ$, $z\,^1G^\circ$, $y\,^1G^\circ$, $x\,^1G^\circ$, $z\,^1H^\circ$,
					$y\,^1H^\circ$, 500°, 527°.
d^4	$a\,^3D_1$	13118.62	360.88	.512	$z\,^3S^\circ$, $y\,^3D^\circ$, $z\,^3F^\circ$, $z\,^3G^\circ$, $z\,^3S^\circ$, $z\,^3P^\circ$, $y\,^3P^\circ$, $z\,^1P^\circ$, $\phi p\,(^1F)$
	$a\,^3D_2$	13479.50	−424.81	1.002	$z\,^1D^\circ$, $y\,^1D^\circ$, $z\,^1D^\circ$, $w\,^1D^\circ$, $v\,^1D^\circ$, $u\,^1D^\circ$, $z\,^1F^\circ$,
	$a\,^3D_3$	13054.69		1.246	$y\,^3F^\circ$, $z\,^1F^\circ$, $w\,^1F^\circ$, $v\,^1F^\circ$, $u\,^1F^\circ$, $z\,^1G^\circ$, $y\,^1G^\circ$, $z\,^1G^\circ$, $\phi p\,(^1F)$
					$w\,^1G^\circ$, $y\,^1H^\circ$, $z\,^1S^\circ$, $z\,^1P^\circ$, $y\,^1P^\circ$, $z\,^1D^\circ$, $z\,^1F^\circ$, $y\,^1F^\circ$,
					$z\,^1F^\circ$, 500°, 527°.
$d^3\,s$	$b\,^3P_0$	14678.40	−52.14	0/0	$z\,^3S^\circ$, $z\,^3P^\circ$, $y\,^3D^\circ$, $z\,^3S^\circ$, $y\,^3S^\circ$, $z\,^3P^\circ$, $y\,^3P^\circ$, $z\,^1P^\circ$,
	$b\,^3P_1$	14626.26	34.51	1.504	$y\,^3D^\circ$, $x\,^3D^\circ$, $w\,^3D^\circ$, $v\,^3D^\circ$, $u\,^3D^\circ$, $y\,^1P^\circ$, $u\,^1P^\circ$,
	$b\,^3P_2$	14660.77		1.483	$y\,^3G^\circ$, $z\,^3G^\circ$, $w\,^3G^\circ$, $z\,^1P^\circ$, $y\,^1P^\circ$, $z\,^1D^\circ$, $y\,^1D^\circ$, $\phi p\,(^1F)$
					$z\,^1D^\circ$, $z\,^1F^\circ$, $y\,^1F^\circ$, $z\,^1F^\circ$, 527°.
d^4	$a\,^1G_4$	14790.79		1.083	$z\,^3P^\circ$, $z\,^1D^\circ$, $y\,^3D^\circ$, $z\,^1F^\circ$, $z\,^1D^\circ$, $y\,^3D^\circ$, $z\,^1D^\circ$, $z\,^1F^\circ$,
					$y\,^1F^\circ$, $w\,^1F^\circ$, $u\,^1F^\circ$, $z\,^1G^\circ$, $y\,^1G^\circ$, $w\,^1G^\circ$, $u\,^1G^\circ$,
					$z\,^1H^\circ$, $y\,^1H^\circ$, $z\,^1I^\circ$, $y\,^1F^\circ$, $x\,^1F^\circ$, $z\,^1G^\circ$, $y\,^1G^\circ$, $z\,^1G^\circ$,
					$z\,^1H^\circ$, $y\,^1H^\circ$.

TABLE 2.—*Terms of the* Cb II *spectrum*—Continued

Electron configuration	Term symbol	Level	Difference	Observed g	Combinations
1	2	3	4	5	6
d^3	$a\,^3I_4$	15396.10		1.000	$z\,^3G^\circ$, $w\,^3G^\circ$, $u\,^3G^\circ$, $z\,^3H^\circ$, $z\,^3I^\circ$, $z\,^1H^\circ$, $y\,^1H^\circ$, $z\,^1I^\circ$.
d^3	$b\,^3G_3$	15551.30	398.10	.767	$z\,^3P^\circ$, $z\,^3D^\circ$, $y\,^3D^\circ$, $z\,^3F^\circ$, $z\,^3P^\circ$, $z\,^3D^\circ$, $y\,^3D^\circ$, $z\,^3D^\circ$, $v\,^3D^\circ$, $u\,^3D^\circ$, $z\,^3F^\circ$, $y\,^3F^\circ$, $x\,^3F^\circ$, $w\,^3F^\circ$, $u\,^3F^\circ$, $z\,^3G^\circ$, $y\,^3G^\circ$, $x\,^3G^\circ$, $w\,^3G^\circ$, $u\,^3G^\circ$, $z\,^3H^\circ$, $y\,^3H^\circ$, $z\,^1D^\circ$, $z\,^1F^\circ$, $y\,^1F^\circ$, $z\,^1F^\circ$, $z\,^1G^\circ$, $y\,^1G^\circ$, $z\,^1H^\circ$, $y\,^1H^\circ$.
d^3	$b\,^3G_4$	15949.40	103.32	1.027	
d^3	$b\,^3G_5$	16052.72		1.190	
d^3	$b\,^1G_4$	16219.04		.950	$z\,^3P^\circ$, $y\,^3D^\circ$, $y\,^1D^\circ$, $z\,^3F^\circ$, $y\,^3F^\circ$, $x\,^3F^\circ$, $w\,^3F^\circ$, $u\,^3F^\circ$, $y\,^1G^\circ$, $x\,^3G^\circ$, $w\,^3G^\circ$, $u\,^3G^\circ$, $y\,^3H^\circ$, $z\,^1I^\circ$, $z\,^1F^\circ$, $y\,^1F^\circ$, $x\,^1F^\circ$, $y\,^1G^\circ$, $x\,^1G^\circ$, $z\,^1H^\circ$, $y\,^1H^\circ$, 500°, 527°.
d^4	$a\,^3S_1$	17202.72		0/0	$y\,^5D^\circ$, $y\,^3S^\circ$, $z\,^3P^\circ$, $z\,^3D^\circ$, $z\,^1P^\circ$, $y\,^1P^\circ$.
d^3	$b\,^3H_4$	17469.77	−177.28	.880	$y\,^3D^\circ$, $y\,^3D^\circ$, $z\,^3F^\circ$, $y\,^3F^\circ$, $z\,^3F^\circ$, $w\,^3F^\circ$, $y\,^3F^\circ$, $u\,^3F^\circ$, $y\,^3G^\circ$, $x\,^3G^\circ$, $w\,^3G^\circ$, $u\,^3G^\circ$, $z\,^3H^\circ$, $y\,^3H^\circ$, $z\,^1F^\circ$, $z\,^1F^\circ$, $z\,^1G^\circ$, $y\,^1G^\circ$, $x\,^1G^\circ$, $y\,^1H^\circ$, $z\,^1I^\circ$, 527°.
d^3	$b\,^3H_5$	17292.49	132.39	1.052	
d^3	$b\,^3H_6$	17424.88		1.154	
d^4	$a\,^1F_3$	18508.15		1.007	$y\,^5D^\circ$, $y\,^3P^\circ$, $z\,^3D^\circ$, $z\,^3F^\circ$, $w\,^3F^\circ$, $v\,^3F^\circ$, $z\,^3G^\circ$, $x\,^3G^\circ$, $w\,^3G^\circ$, $x\,^1D^\circ$, $y\,^1F^\circ$, $z\,^1G^\circ$, $y\,^1G^\circ$, $x\,^1G^\circ$.
d^3	$b\,^3D_1$	18819.57	532.41	.681	$z\,^3S^\circ$, $z\,^3P^\circ$, $y\,^3D^\circ$, $z\,^3F^\circ$, $z\,^3S^\circ$, $z\,^3P^\circ$, $y\,^3P^\circ$, $x\,^3P^\circ$, $w\,^3P^\circ$, $y\,^3D^\circ$, $x\,^3D^\circ$, $w\,^3D^\circ$, $v\,^3D^\circ$, $u\,^3D^\circ$, $z\,^3F^\circ$, $y\,^3F^\circ$, $x\,^3F^\circ$, $w\,^3F^\circ$, $v\,^3F^\circ$, $u\,^3F^\circ$, $y\,^3G^\circ$, $x\,^3G^\circ$, $u\,^3G^\circ$, $y\,^3H^\circ$, $z\,^1D^\circ$, $y\,^1D^\circ$, $z\,^1D^\circ$, $z\,^1F^\circ$, $y\,^1F^\circ$, $z\,^1G^\circ$, $y\,^1G^\circ$.
d^3	$b\,^3D_2$	19351.98	337.56	1.171	
d^3	$b\,^3D_3$	19689.54		1.312	
d^4	$c\,^3P_0$	20347.55	692.01	0/0	$z\,^5S^\circ$, $y\,^1D^\circ$, $z\,^3S^\circ$, $y\,^3S^\circ$, $z\,^1P^\circ$, $y\,^1P^\circ$, $x\,^1P^\circ$, $y\,^3D^\circ$, $x\,^3D^\circ$, $w\,^3D^\circ$, $z\,^3D^\circ$, $u\,^3D^\circ$, $y\,^3F^\circ$, $x\,^3F^\circ$, $w\,^3F^\circ$, $v\,^3F^\circ$, $w\,^3G^\circ$, $v\,^3G^\circ$, $z\,^3S^\circ$, $y\,^3S^\circ$, $z\,^1D^\circ$, $z\,^1F^\circ$.
d^4	$c\,^3P_1$	21039.56	471.90	1.218	
d^4	$c\,^3P_2$	21511.46		1.408	
d^4	$a\,^1P_1$	20437.58		1.115	$y\,^1D^\circ$, $z\,^5S^\circ$, $z\,^3P^\circ$, $y\,^3P^\circ$, $x\,^3P^\circ$, $y\,^3D^\circ$, $z\,^3D^\circ$, $w\,^3D^\circ$, $y\,^3F^\circ$, $v\,^3F^\circ$, $u\,^3F^\circ$, $z\,^1S^\circ$, $z\,^1P^\circ$, $y\,^1P^\circ$, $z\,^1D^\circ$, $x\,^1D^\circ$, 495°.
d^4	$c\,^1F_3$	20657.52	459.55	.670	$z\,^3D^\circ$, $y\,^1D^\circ$, $z\,^1F^\circ$, $z\,^3P^\circ$, $y\,^3P^\circ$, $x\,^3P^\circ$, $z\,^3D^\circ$, $y\,^3D^\circ$, $x\,^3D^\circ$, $w\,^3D^\circ$, $v\,^3D^\circ$, $u\,^3D^\circ$, $z\,^3F^\circ$, $y\,^3F^\circ$, $x\,^3F^\circ$, $w\,^3F^\circ$, $v\,^3F^\circ$, $u\,^3F^\circ$, $z\,^3G^\circ$, $y\,^3G^\circ$, $x\,^3G^\circ$, $w\,^3G^\circ$, $u\,^3G^\circ$, $y\,^3H^\circ$, $z\,^1P^\circ$, $y\,^1P^\circ$, $z\,^1D^\circ$, $y\,^1D^\circ$, $z\,^1F^\circ$, $y\,^1F^\circ$, $x\,^1F^\circ$, 500°, 527°.
d^4	$c\,^3F_3$	21117.47	355.05	1.080	
d^4	$c\,^3F_4$	21472.52		1.240	
d^4	$a\,^1H_5$	21073.05		.993	$y\,^1D^\circ$, $y\,^1F^\circ$, $w\,^1F^\circ$, $y\,^3G^\circ$, $x\,^3G^\circ$, $w\,^3G^\circ$, $u\,^3G^\circ$, $z\,^1H^\circ$, $y\,^1H^\circ$, $z\,^1I^\circ$, $z\,^1G^\circ$, $y\,^1G^\circ$, $x\,^1G^\circ$, $y\,^1H^\circ$, $z\,^1I^\circ$.
d^4	$b\,^1D_2$	24332.87		.98	$z\,^3P^\circ$, $x\,^3P^\circ$, $y\,^3D^\circ$, $x\,^3D^\circ$, $w\,^3D^\circ$, $v\,^3D^\circ$, $v\,^3F^\circ$, $u\,^3F^\circ$, $x\,^3G^\circ$, $y\,^1P^\circ$, $y\,^1D^\circ$, $y\,^1F^\circ$, 527°.
d^4	$d\,^3F_2$	25414.24	−60.58	.71	$y\,^3P^\circ$, $x\,^3P^\circ$, $z\,^3D^\circ$, $w\,^3D^\circ$, $v\,^3D^\circ$, $u\,^3D^\circ$, $y\,^3F^\circ$, $x\,^3F^\circ$, $w\,^3F^\circ$, $v\,^3F^\circ$, $u\,^3F^\circ$, $x\,^3G^\circ$, $w\,^3G^\circ$, $u\,^3G^\circ$, $y\,^1F^\circ$, $x\,^1F^\circ$, 500°, 527°.
d^4	$d\,^3F_3$	25353.66	3.84	.93	
d^4	$d\,^3F_4$	25357.50			
d^4	$d\,^3P_0$	28001.37	−207.22	0/0	$y\,^5D^\circ$, $y\,^3S^\circ$, $z\,^3P^\circ$, $z\,^3D^\circ$, $w\,^3D^\circ$, $u\,^3D^\circ$, 495°.
d^4	$d\,^3P_1$	27794.15	−511.97	1.49	
d^4	$d\,^3P_2$	27282.18		1.49	
d^3	$c\,^1G_4$	29634.24		1.087	$v\,^5D^\circ$, $y\,^3F^\circ$, $y\,^1H^\circ$, $z\,^1F^\circ$, $x\,^1F^\circ$, $y\,^1G^\circ$, $x\,^1G^\circ$, $y\,^1H^\circ$.
d^4	$c\,^1D_2$	31064.80		1.01	$y\,^1D^\circ$, $y\,^1P^\circ$, $y\,^3S^\circ$, 527°, $x\,^1F^\circ$, $x\,^1D^\circ$.
d^3	$b\,^1F_3$	31762.31		1.01	$v\,^3F^\circ$, $w\,^3G^\circ$, $y\,^1D^\circ$, $x\,^1D^\circ$, $x\,^1F^\circ$, $z\,^1G^\circ$, $y\,^1G^\circ$, $x\,^1G^\circ$.
d^3p (4F)	$z\,^5G_2^\circ$	*33351.00*	568.20	.345	$a\,^5D$, $a\,^5F$, $a\,^3D$, $a\,^3F$, $b\,^3F$, $a\,^3G$.
	$z\,^5G_3^\circ$	*33919.90*	712.80	.913	
	$z\,^5G_4^\circ$	*34632.00*	842.17	1.152	
	$z\,^5G_5^\circ$	*35474.17*	981.30	1.250	
	$z\,^5G_6^\circ$	*36455.47*		1.31	
d^3p (4F)	$z\,^3D_1^\circ$	*34886.33*	634.50	.420	$a\,^3P$, $a\,^3D$, $a\,^1F$, $a\,^3P$, $a\,^1D$, $a\,^3F$, $b\,^3F$, $c\,^3F$, $a\,^3G$, $b\,^3G$, $a\,^3H$, $a\,^1G$.
	$z\,^3D_2^\circ$	*35520.83*	1032.44	1.138	
	$z\,^3D_3^\circ$	*36553.27*		1.311	
d^3p (4F)	$z\,^1F_3^\circ$	*36751.79*	230.97	.122	$a\,^3D$, $a\,^1F$, $a\,^3P$, $c\,^3P$, $a\,^1D$, $b\,^3D$, $a\,^3F$, $b\,^3F$, $c\,^3F$, $a\,^3G$, $b\,^3G$, $a\,^3H$, $a\,^1G$.
	$z\,^1F_2^\circ$	*36982.76*	414.15	1.023	
	$z\,^1F_3^\circ$	*37376.91*	151.46	1.266	
	$z\,^1F_4^\circ$	*37528.39*	495.93	1.325	
	$z\,^1F_1^\circ$	*38084.32*		1.357	
d^3p (4F)	$z\,^1D_2^\circ$	*37298.80*	181.83	0/0	$a\,^1P$, $a\,^3D$, $a\,^1F$, $a\,^3P$, $a\,^1F$, $b\,^1F$, $c\,^3F$, $a\,^3G$, $b\,^3G$, $a\,^3H$, $a\,^1G$.
	$z\,^1D_1^\circ$	*37480.03*	317.26	1.460	
	$z\,^1D_2^\circ$	*37797.29*	419.08	1.469	
	$z\,^1D_3^\circ$	*38216.37*	74.88	1.466	
	$z\,^1D_1^\circ$	*38291.25*		1.473	

TABLE 2.—*Terms of the* Cb II *spectrum*—Continued

Electron configuration	Term symbol	Level	Difference	Observed g	Combinations
1	2	3	4	5	6
$d^3\,p\,(^4F)$	$z\,^5G_3^1$	*38684.96*	660.34	.764	$a\,^5D, a\,^3F, a\,^3P, a\,^3D, a\,^5F, b\,^3F, c\,^3F, a\,^3G, b\,^3G, a\,^3H,$
	$z\,^5G_4^1$	*39335.30*	768.31	1.072	$a\,^1F, a\,^1G.$
	$z\,^5G_5^1$	*40103.61*		1.234	
$d^3\,p\,(^4F)$	$z\,^5F_1^1$	*38984.40*	795.55	.691	$a\,^3P, a\,^5D, a\,^3F, a\,^3P, a\,^3D, b\,^5D, a\,^5F, b\,^5F, c\,^3F, a\,^3G,$
	$z\,^5F_2^1$	*39779.95*	781.05	1.068	$b\,^3G, a\,^3H, b\,^3H, a\,^1D, a\,^1F, a\,^1G, b\,^1G.$
	$z\,^5F_3^1$	*40561.00*		1.200	
$d^3\,p\,(^2P)$	$z\,^3S_1^1$	*39791.90*		0/0	$a\,^3P, c\,^3P, a\,^3D, a\,^1P.$
$d^3\,p\,(^2P)$	$z\,^1D_2^1$	*41710.15*		1.312	$a\,^3P, a\,^5D, b\,^3P, c\,^3P, a\,^3D, b\,^3D, a\,^3F, b\,^3F, c\,^1F, a\,^1G,$
					$b\,^1G, a\,^1P, a\,^1D, b\,^1D.$
$d^3\,p\,(^4P)$	$y\,^5D_0^1$	*42896.58*		0/0	
	$y\,^5D_1^1$	*42192.70*	−403.88	1.385	
	$y\,^5D_2^1$	*43678.35*	1485.65	1.347	$a\,^3P, a\,^5D, a\,^3P, b\,^3P, c\,^3P, d\,^3P, a\,^3D, b\,^3D, a\,^3F, b\,^3F,$
	$y\,^5D_3^1$	*43867.00*	268.65	1.447	$c\,^3F, b\,^3G, a\,^1S, a\,^1P, a\,^1D, a\,^1F, a\,^1G, b\,^1G, a\,^1H.$
	$y\,^5D_4^1$	*44970.73*	1083.73	1.480	
$d^3\,p\,(^3G)$	$z\,^5H_3^1$	*42668.97*		.810	
	$z\,^5H_4^1$	*43567.93*	668.96	1.040	$a\,^1D, b\,^3F, a\,^3G, b\,^1G, a\,^3H, b\,^3H, a\,^1G, b\,^1G, a\,^1H, a\,^1I.$
	$z\,^5H_5^1$	*44532.40*	964.47	1.167	
$d^3\,p\,(^4P)$	$y\,^5D_1^1$	*42649.19*		.980	
	$y\,^5D_2^1$	*43290.54*	−358.85	1.227	$a\,^3P, a\,^5D, a\,^3P, b\,^3P, c\,^3P, a\,^3D, b\,^3D, a\,^3F, b\,^3F, c\,^1F,$
	$y\,^5D_3^1$	*44638.77*	1348.43	1.035	$a\,^3G, b\,^3G, a\,^3H, b\,^3H, a\,^1P, a\,^1D, b\,^1D, a\,^1G, b\,^1G.$
$d^3\,p\,(^4P)$	$z\,^5P_1^1$	*42450.00*		2.255	
	$z\,^5P_2^1$	*43226.81*	776.81	1.745	$a\,^3P, a\,^5D, a\,^3P, b\,^3P, b\,^5D, a\,^3F, a\,^3G, b\,^3G, a\,^3H,$
	$z\,^5P_3^1$	*44771.47*	544.66	1.562	$a\,^1D, a\,^1G, b\,^1G.$
$d^3\,p\,(^4P)$	$z\,^5P_0^1$	*44886.00*		0/0	
	$z\,^5P_1^1$	*44666.66*	−219.35	1.230	$a\,^3P, a\,^5D, a\,^3F, a\,^3P, b\,^3P, c\,^3P, a\,^3D, b\,^3D, a\,^3F, b\,^3F,$
	$z\,^5P_2^1$	*44984.59*	837.94	1.253	$c\,^3F, b\,^3G, a\,^1P, a\,^1D, b\,^1D.$
$d^3\,p\,(^2F)$	$y\,^3P_2^1$	*45806.59*		0/0	
	$y\,^3P_1^1$	*45374.96*	168.37	1.765	$a\,^3P, a\,^5D, a\,^3F, a\,^3P, b\,^3P, c\,^3P, a\,^3D, b\,^3D, a\,^3F, b\,^3F,$
	$y\,^3P_0^1$	*46545.23*	1170.32	1.506	$c\,^3F, d\,^3F, a\,^1P, a\,^1D, a\,^1F.$
$d^3\,p\,(^2G)$	$z\,^1H_5^1$	*45342.25*		1.018	$a\,^3F, b\,^3F, a\,^3G, b\,^3G, a\,^3H, b\,^3H, a\,^1G, b\,^1G, a\,^1H, a\,^1I.$
$d^3\,p\,(^2G)$	$y\,^3F_4^1$	*45655.24*		.740	
	$y\,^3F_3^1$	*46428.03*	772.79	1.123	$a\,^3P, a\,^3F, b\,^3P, c\,^3P, a\,^3D, b\,^3D, a\,^3F, b\,^3F, c\,^1F, d\,^1F,$
	$y\,^3F_2^1$	*46295.61*	−133.02	1.111	$a\,^1G, b\,^1G, a\,^3H, b\,^3H, a\,^1P, a\,^1D, a\,^1G, b\,^1G, c\,^1G,$
					$a\,^1H.$
$d^3\,p\,(^2G)$	$y\,^3G_5^1$	*45919.08*		1.014	
	$y\,^3G_4^1$	*45621.97*	−297.11	1.126	$a\,^3P, a\,^5D, a\,^3F, b\,^3P, c\,^3P, a\,^3D, b\,^3D, a\,^3F, b\,^3F, c\,^1F,$
	$y\,^3G_3^1$	*46499.62*	877.65	1.171	$a\,^1G, b\,^1G, a\,^1H, b\,^3H, a\,^1D, a\,^1G, b\,^1G, a\,^1H.$
$d^3\,p\,(^2G)$	$z\,^1F_3^1$	*45902.49*		1.085	$a\,^3P, a\,^5D, b\,^3P, c\,^3P, a\,^3D, b\,^3D, a\,^3F, b\,^3F, c\,^1F, a\,^1G,$
					$b\,^3G, a\,^3H, b\,^3H, a\,^1D, a\,^1F, b\,^1F, b\,^1G, c\,^1G.$
$d^3\,p\,(^2D)$	$z\,^3F_2^1$	*46343.10*		.43	
	$z\,^3F_3^1$	*46949.47*	606.37	1.00	$a\,^3P, a\,^3F, c\,^3P, a\,^1D, b\,^3D, a\,^3F, c\,^3F, d\,^3F, a\,^3G, a\,^1H,$
	$z\,^3F_4^1$	*50552.26*	3602.79	1.22	$b\,^3H, a\,^1D, b\,^1G.$
$d^3\,p\,(^2P)$	$z\,^1S_0^1$	*46358.94*		1.821	$a\,^3P, b\,^3P, c\,^3P, a\,^3D, b\,^3D, a\,^3F, b\,^3F, a\,^1P.$
$d^3\,p\,(^2P)$	$z\,^1S_1^1$	*47072.98*		1.940	$a\,^3P, a\,^3P, b\,^3P, c\,^3P, a\,^3D, b\,^3D, a\,^1D.$
$d^3\,p\,(^2H)$	$y\,^3H_5^1$	*47345.18*		.963	
	$y\,^3H_4^1$	*48500.80*	1155.62	1.038	$a\,^3D, a\,^1D, b\,^3D, a\,^3F, b\,^3F, c\,^3F, a\,^3G, b\,^3G, a\,^3H,$
	$y\,^3H_3^1$	*48770.90*	270.10	1.132	$b\,^3H, a\,^1G, b\,^1G, c\,^1G, a\,^1H.$
$d^3\,p\,(^2D)$	$w\,^3F_4^1$	*47755.78*		.63	
	$w\,^3F_3^1$	*48077.67*	321.91	1.065	$a\,^3P, a\,^5D, a\,^3F, c\,^3P, d\,^3P, a\,^3D, b\,^3D, a\,^3F, b\,^3F,$
	$w\,^3F_2^1$	*48627.20*	549.53	1.100	$c\,^3F, d\,^3F, a\,^3G, b\,^3G, a\,^3H, b\,^3H, b\,^1D, a\,^1F, a\,^1G,$
					$b\,^1G, a\,^1H.$
$d^3\,p\,(^2H)$	$z\,^3I_5^1$	*48130.80*		.870	
	$z\,^3I_6^1$	*48617.49*	486.99	1.051	$a\,^3G, b\,^3G, a\,^3H, b\,^3H, a\,^1G, b\,^1G, a\,^3H, a\,^1I.$
	$z\,^3I_7^1$	*49389.78*	772.24	1.15	
$d^3\,p\,(^2G)$	$z\,^1G_4^1$	*48253.44*		1.083	$a\,^5D, a\,^3F, b\,^3D, a\,^3F, b\,^3F, a\,^3G, b\,^3G, a\,^3H, b\,^3H,$
					$a\,^1F, b\,^1F, a\,^1G, a\,^1H.$
$d^3\,p\,(^2P)$	$z\,^1P_1^1$	*48380.41*		.936	$a\,^3P, b\,^1P, c\,^3P, a\,^1D, b\,^3D, a\,^3F, b\,^3F, c\,^3F, a\,^1S, a\,^1P,$
					$a\,^1D.$

TABLE 2.—*Terms of the* Cb II *spectrum*—Continued

Electron configuration	Term symbol	Level	Difference	Observed g	Combinations
1	2	3	4	5	6
$p\,(^3H)$	$y\,^1G_4^\circ$	*49158.16*		.980	$\{a\,^3D, b\,^3D, a\,^3F, b\,^3F, c\,^3F, a\,^3G, b\,^3G, a\,^3H, b\,^3H,$ $a\,^1F, b\,^1F, a\,^1G, b\,^1G, c\,^1G, a\,^1H.$
$p\,sp$	4951	*49330.62*			$a\,^3F, d\,^3P, a\,^3F, a\,^3G, a\,^1P.$
$p\,sp$	$x\,^3D_3^\circ$	*49087.72*		.820	$\{a\,^3F, a\,^3P, b\,^3P, c\,^3P, d\,^3P, a\,^3D, b\,^3D, a\,^3F, b\,^3F,$ $c\,^3F, d\,^3F, a\,^3G, b\,^3G, a\,^1S, a\,^1P, a\,^1D, b\,^1D, a\,^1F.$
	$x\,^3D_2^\circ$	*49245.55*	−442.17	1.257	
	$x\,^3D_1^\circ$	*49759.19*	513.64	1.288	
$p\,(^3D)$	$w\,^3D_3^\circ$	*49733.45*		.616	$\{a\,^3P, a\,^3F, a\,^1P, b\,^3P, c\,^3P, d\,^3P, a\,^3D, b\,^3D, a\,^3F,$ $b\,^3F, c\,^3F, d\,^3F, a\,^3G, a\,^1P, a\,^1D.$
	$w\,^3D_2^\circ$	*49772.30*	38.85	1.167	
	$w\,^3D_1^\circ$	*49864.25*	91.95	1.308	
$d\,sp$	5001	*50068.70*		1.245	$a\,^3F, a\,^3P, e\,^3P, a\,^3D, b\,^3F, c\,^3F, d\,^3F, b\,^1G.$
$p\,(^3D)$	$x\,^3P_2^\circ$	*50295.20*		0/0	$\{a\,^3P, a\,^3F, a\,^1P, b\,^3P, c\,^3P, a\,^3D, b\,^3D, a\,^3F, b\,^3F,$ $c\,^3F, a\,^1P, a\,^1D.$
	$x\,^3P_1^\circ$	*50474.92*	179.72	1.202	
	$x\,^3P_0^\circ$	*50447.36*	−27.56	1.360	
$p\,(^3H)$	$x\,^1G_4^\circ$	*50585.31*		.811	$\{a\,^3P, a\,^3F, a\,^1P, b\,^3P, a\,^3D, b\,^3D, a\,^3F, b\,^3F, c\,^3F,$ $d\,^3F, a\,^3G, b\,^3G, a\,^3H, b\,^3H, a\,^1D, b\,^1D, a\,^1F, b\,^1G,$ $a\,^1H, a\,^1I.$
	$x\,^3G_5^\circ$	*50851.70*	266.39	1.171	
	$x\,^3G_4^\circ$	*50497.90*	−353.80	1.188	
$p\,(^3D)$	$y\,^1D_2^\circ$	*51188.16*		.905	$\{a\,^3F, b\,^3P, c\,^3P, a\,^3D, b\,^3D, a\,^3F, b\,^3F, c\,^3F, d\,^3F,$ $a\,^3G, a\,^1D, b\,^1D, b\,^1F.$
$p\,(^3H)$	$z\,^1I_6$	*51707.49*		1.010	$a\,^3F, a\,^3G, a\,^3H, b\,^3H, a\,^1H, a\,^1I.$
$p\,(^3D)$	$y\,^1P_1^\circ$	*51787.87*		1.13	$\{a\,^3P, a\,^3P, b\,^3P, c\,^3P, d\,^3P, a\,^3D, b\,^3F, c\,^3F, a\,^1S,$ $a\,^1P, a\,^1D, b\,^1D.$
$p\,(^3F)$	$v\,^3F_4^\circ$	*51927.28*		.80	$\{a\,^3P, a\,^3F, a\,^3P, c\,^3P, a\,^3D, b\,^3D, a\,^3F, b\,^3F, c\,^3F,$ $d\,^3F, a\,^3G, a\,^1H, b\,^3H, a\,^1P, a\,^1D, b\,^1D, a\,^1F, b\,^1F.$
	$v\,^3F_3^\circ$	*51936.59*	9.11	1.065	
	$v\,^3F_2^\circ$	*52279.64*	343.25	1.261	
$d\,sp$	$w\,^3P_2^\circ$	*52189.80*		0/0	$a\,^3P, a\,^3F, b\,^3D, c\,^3F, a\,^3G.$
	$w\,^3P_1^\circ$	*52214.85*	85.05	1.43	
	$w\,^3P_0^\circ$	*52388.59*	173.74	1.44	
$p\,(^3P)$	$y\,^3S_1^\circ$	*52553.90*		1.820	$a\,^3P, a\,^3P, b\,^3P, c\,^3P, d\,^3P, a\,^3F, a\,^1S.$
$d\,sp$	5271	*52714.88*		1.415	$a\,^3P, a\,^3F, b\,^3P, a\,^3D, a\,^1F, b\,^3F, c\,^3F, d\,^3F, a\,^3G,$ $b\,^3H, a\,^1D, b\,^1G.$
$p\,(^3H)$	$y\,^1H_5^\circ$	*52758.10*		1.006	$b\,^3F, c\,^3F, b\,^3G, b\,^3H, a\,^1G, b\,^1G, c\,^1G, a\,^1H, a\,^1I.$
$p\,(^3D)$	$y\,^1F_3^\circ$	*53056.96*		1.036	$a\,^3P, a\,^3F, b\,^3P, a\,^3D, b\,^3D, a\,^1F, b\,^3F, c\,^3F, d\,^3F, a\,^3G,$ $b\,^3G, a\,^3H, a\,^1D, b\,^1D, a\,^1F, a\,^1G, b\,^1G.$
$p\,(^3F)$	$w\,^3G_5^\circ$	*53709.08*		.88	$\{a\,^3F, b\,^3P, a\,^3D, a\,^3F, b\,^3F, c\,^3F, d\,^3F, a\,^3G, b\,^3G, a\,^3H,$ $b\,^3H, a\,^1D, a\,^1F, b\,^1F, a\,^1G, b\,^1G, a\,^1H, a\,^1I.$
	$w\,^3G_4^\circ$	*53428.57*	726.55	1.062	
	$w\,^3G_3^\circ$	*53021.20*	502.63	1.180	
$p\,(^3F)$	$v\,^3D_3^\circ$	*54172.60*		.827	$\{a\,^3P, a\,^3F, a\,^3P, b\,^3P, c\,^3P, a\,^3D, b\,^3D, b\,^3F, c\,^3F, d\,^3F,$ $a\,^3G, b\,^3G, a\,^3H, b\,^3H, a\,^1D, b\,^1D, a\,^1G, c\,^1G.$
	$v\,^3D_2^\circ$	*54124.80*	−47.80	1.164	
	$v\,^3D_1^\circ$	*54009.50*	−115.30	1.200	
$p\,(^3F)$	$x\,^1F_3^\circ$	*55460.54*		1.06	$b\,^3P, a\,^3D, b\,^3F, c\,^3F, d\,^3F, b\,^1G, b\,^3H, a^1D, b\,^1F, b\,^1G,$ $c\,^1G.$
$p\,(^3F)$	$x\,^1D_2^\circ$	*55781.74*		1.000	$b\,^3P, c\,^3P, b\,^3D, a\,^3F, a\,^1P, a\,^1D, b\,^1D, a\,^1F, b\,^1F.$
$p\,(^3F)$	$x\,^1G_4^\circ$	*57145.86*		1.000	$b\,^3F, b\,^3H, a\,^1F, b\,^1F, a\,^1G, b\,^1G, a\,^1H.$
$p\,sp\,(^1F)$	$u\,^3F_4^\circ$	*57808.35*		.98	$\{a\,^3P, b\,^3P, a\,^3D, b\,^3D, a\,^3F, b\,^3F, c\,^3F, d\,^3F, a\,^3G, b\,^3G,$ $b\,^3H, a\,^1P, b\,^1D, a\,^1G, b\,^1G.$
	$u\,^3F_3^\circ$	*58503.19*	694.08	1.25	
	$u\,^3F_2^\circ$	*58599.80*	897.37	1.34	
$p\,sp\,(^1F)$	$u\,^3D_3^\circ$	*59022.96*		.64	$\{b\,^3P, c\,^3P, d\,^3P, a\,^3D, b\,^3D, a\,^3F, b\,^3F, c\,^3F, d\,^3F, b\,^1G,$ $a\,^3H.$
	$u\,^3D_2^\circ$	*59497.02*	−125.24	1.19	
	$u\,^3D_1^\circ$	*59705.50*	208.48	1.33	
$p\,sp\,(^1F)$	$v\,^3G_5^\circ$	*59509.23*			$\{b\,^3D, a\,^3F, b\,^3F, c\,^3F, d\,^3F, a\,^3G, b\,^3G, a\,^3H, b\,^3H, a\,^1G,$ $b^3G, a\,^1H.$
	$v\,^3G_4^\circ$	*60094.50*	585.27		
	$v\,^3G_3^\circ$	*60439.75*	345.25	1.19	

The observed g-values (magnetic splitting factors) entered in colum 5 of table 2 may be compared with Landé values for LS-coupling b referring to published tables [17]. Many departures from theoretica LS-values will be noticed, but the larger deviations apparently resul from g-sharing rather than from jj-coupling. An interesting exampl is $z\,^5F_1^\circ$ the g-value of which is observed to be 0.122 instead of 0.00 as required by theory. There are two other levels, $z\,^3D_1^\circ$ and $z\,^5D_1^\circ$ associated with $z\,^5F_1^\circ$, and their deficiency in theoretical g-valu amounts to 0.120. Summing all g-values for levels ascribed to give electron configurations leads to the following results. The g-sum fo 38 levels originating with d^4 is 33.016, compared with the Landé sum 33.000. The sum for 75 levels ascribed to $d^3\,p$ is 104.23, compare with the Landé sum 105.00.

The combining properties of the terms are displayed in the las column of table 2. All combinations obey the selection rules $\Delta L=0$ ±1, ±2, ±3, and $\Delta J=0$ (except 0 to 0), ±1, but, as usual, not a permitted combinations have been observed, either because of lo intensity or masking by stronger lines. The total number of observe combinations of terms is 619, of which 60 are singlet-singlet, 23 triplet-triplet, 12 quintet-quintet, 174 singlet-triplet, 24 singlet quintet, 89 triplet-quintet, and 22 with 3 unidentified odd levels.

Since the number of levels and combinations was greatly increase in this analysis as compared with the earlier one [5], it was necessar to adjust some of the older values. Three of the old levels (11047.15 40231.97, 44936.01) were not confirmed by the Zeeman effect—the have been replaced by genuine levels.

3. ELECTION CONFIGURATIONS, THEORETICAL AND OBSERVE TERMS

Columbium has atomic number 41 and the extra-nuclear structur of neutral columbium atoms is represented by $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}$ $4s^2\,4p^6\,4d^4\,5s$ (see below). Chemical valence and the first optica spectrum (Cb I) are associated with the last five electrons, and if on of these is removed by ionization, the ion may emit the second spectrum (Cb II) characteristic of four valence electrons. These four may b distributed in various ways, and each configuration produces different family of (even) spectral terms (atomic energy states) a follows:

$4d^4$, ^{1}(SDG), ^{3}(PF), ^{1}(SDFGI), ^{3}(PDFGH), ^{5}(D).
$4d^3\,5s$, ^{1,3}(D), ^{1,3}(PDFGH), ^{3,5}(PF).
$4d^2\,5s^2$, ^{1}(SDG), ^{3}(PF).

In this analysis of the Cb II spectrum, all the $4d^4$ terms have bee found except the highest ^{1}S, all the $4d^3\,5s$ terms except the highes ^{1,3}(D), but no trace of $4d^2\,5s^2$ terms that yield the ground state of th Zr I spectrum, which Cb II should resemble, according to the dis placement law. Similar results were reported and explained for th V II spectrum [7].

Almost all the observed Cb II lines arise from combinations of th levels from (even) $4d^4$ or $4d^3\,5s$ configurations with excited state associated with (odd) configurations $4d^3\,5p$ or $4d^2\,5s5p$. The predicte and observed terms from these configurations are displayed in table

The lines remaining unclassified are too scattered and few to fix further terms with certainty. Efforts to use them for this purpose, in particular to find series-forming terms from the configuration $4d^3\,6s$, proved futile, and it appears that the spectroscopic ionization potential of Cb^+ cannot be determined without study of the Cb II spectrum from a source that favors the development of series terms. The evidence from other spectra indicates that the principal ionization potential of Cb^+ will be about 14 volts.

TABLE 3.—Cb II *predicted and observed terms*

Electron configuration	Limit Cb III	Predicted	Observed
$4d^4$		^{1}D, ^{1}(PF) ^{3}(PDFGH) ^{1}(SDFGI) ^{1}(SDG)	$a\,^1$D, $d\,^3$P, $c\,^3$F $a\,^3$P, $a\,^3$D, $b\,^3$F, $a\,^3$G, $a\,^3$H $a\,^1$S, $a\,^1$D, $a\,^1$F, $a\,^1$G, $a\,^1$I --, $c\,^1$D, $c\,^1$G
$4d^3\,5s$	^{4}F	^{5}F, ^{3}F	$a\,^5$F, $a\,^3$F
	^{4}P	^{5}P, ^{3}P	$a\,^5$P, $c\,^3$P
	^{2}P	^{3}P, ^{1}P	$b\,^3$P, $a\,^1$P
	^{2}D	^{3}D, ^{1}D	$b\,^3$D, $b\,^1$D
	^{2}F	^{3}F, ^{1}F	$d\,^3$F, $b\,^1$F
	^{2}G	^{3}G, ^{1}G	$b\,^3$G, $b\,^1$G
	^{2}H	^{3}H, ^{1}H	$b\,^3$H, $a\,^1$H
	(^{2}D)	^{3}D, ^{1}D	--, --
$4d^3\,5p$	^{4}F	^{5}(DFG), ^{3}(DFG)	$z\,^5$D°, $z\,^3$F°, $z\,^5$G°, $z\,^3$D°, $z\,^3$F°, $z\,^3$G°
	^{4}P	^{5}(SPD), ^{3}(SPD)	$z\,^5$S°, $z\,^5$P°, $y\,^5$D°, $y\,^3$S°, $z\,^3$P°, $y\,^3$D°
	^{2}P	^{3}(SPD), ^{1}(SPD)	$z\,^3$S°, $y\,^3$P°, $z\,^3$D°, $z\,^1$S°, $z\,^1$P°, $z\,^1$D°
	^{2}D	^{3}(PDF), ^{1}(PDF)	$x\,^3$P°, $w\,^3$D°, $x\,^3$F°, $y\,^1$P°, $y\,^1$D°, $y\,^1$F°
	^{2}F	^{3}(DFG), ^{1}(DFG)	$v\,^3$D°, $w\,^3$F°, $w\,^3$G°, $x\,^1$D°, $x\,^1$F°, $x\,^1$G°
	^{2}G	^{3}(FGH), ^{1}(FGH)	$y\,^3$F°, $y\,^3$G°, $z\,^3$H°, $z\,^1$F°, $z\,^1$G°, $z\,^1$H°
	^{2}H	^{3}(GHI), ^{1}(GHI)	$z\,^3$G°, $y\,^3$H°, $z\,^3$I°, $y\,^1$G°, $y\,^1$H°, $z\,^1$I°
	(^{2}D)	^{3}(PDF), ^{1}(PDF)	--, --, --, --, --, --
$4d^3\,5s\,5p$	^{4}F	^{5}(DFG), ^{3}(DFG)	--, --, --, $u\,^3$D°, $v\,^3$F°, $v\,^3$G°
	^{4}P	^{5}(SPD), ^{3}(SPD)	--, --, --, --, --, --
	^{2}S	^{3}P, ^{1}P	--, --, --, --, --, --
	^{2}P	^{3}(SPD), ^{1}(SPD)	--, --, --, --, --, --
	^{2}D	^{3}(PDF), ^{1}(PDF)	--, --, --, --, --, --
	^{2}F	^{3}(DFG), ^{1}(DFG)	--, --, --, --, --, --
	^{2}G	^{3}(FGH), ^{1}(FGH)	--, --, --, --, --, --

IV. TERM ANALYSIS OF Cb I

1. LINES OF THE Cb I SPECTRUM

The data for the lines of Cb I, characteristic of neutral Cb atoms, are displayed in table 4, which is prepared according to the same plan as table 1 for Cb II. Column 1 shows the estimated intensity and character, column 2 the measured wavelength, column 3 the vacuum wave number, column 4 the term combinations, and the last six columns contain data on the Zeeman effect. There are 3,313 entries in the table, comprising all classified lines and nearly all unclassified lines, only those of doubtful origin and very weak lines of estimated intensity 2 or less being omitted. Where a line is classified in two or more ways, the more probable transition is written first. In many instances these double classifications are unresolved blends, the measured position falling between the calculated positions of the respective components. Statistical information as to classification and distribution of the classified lines into various categories is given in table 5.

TABLE 4.—*First spectrum of columbium* (Cb I)

?=Observed and calculated wave numbers disagree by 0.2 cm^{-1} or more.
*=Leads to value of observed g showing excessive variation from values derived from other patterns. Components of opposite polarization only used in reduction if present.
†=Classification not in agreement with observed Zeeman effect. Possibly fortuitous.
‡=Zeeman components show resolved hyperfine structure.
**=Unaffected by magnetic field.
w=Unresolved.
L=Landé g assumed.

Intensity Arc	λ_{air} A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest σ	Strongest π	g_1	g_2
1	2	3	4	5	6	7	8	9	10
5c	10920.7	9154.4	a $^4G_{11/2}$–z $^4D_{9/2}$						
5c	10907.9	9165.1							
3	10872.6	9194.9							
5	10863.2	9202.9							
3	10706.8	9337.3	b $^2H_{9/2}$–y $^4F_{7/2}$						
2	10663.3	9375.4	a $^4G_{11/2}$–z $^4D_{5/2}$						
4	10636.54	9399.02							
7	10588.70	9441.44							
10c	10563.7	9463.8							
4	10533.72	9490.73	b $^4D_{3/2}$–z $^2D_{5/2}$						
5c	10525.50	9498.14	a $^2P_{3/2}$–z $^4D_{5/2}$?						
3	10522.7	9500.6							
5c	10496.22	9524.64							
3	10460.87	9556.82							
3	10452.53	9564.46							
3	10448.37	9568.26							
10c	10419.54	9594.73							
5c	10249.56	9753.84							
2	10229.04	9773.41	b $^4P_{1/2}$–y $^4F_{3/2}$?						
8c	10203.44	9797.94							
10c	10181.33	9819.21	b $^2G_{9/2}$–y $^2G_{9/2}$						
3	10156.57	9843.15							
4	10100.92	9898.57							
5c	10084.46	9913.53	b $^2G_{9/2}$–y $^4D_{5/2}$						
20c	10067.4	9930.3	a $^4D_{3/2}$–z $^4F_{5/2}$						
10c	10042.54	9954.91	b $^4F_{3/2}$–z $^4G_{5/2}$						
2	10019.40	9977.91	b $^2G_{7/2}$–z $^2G_{7/2}$						
30c	10003.85	9993.41	a $^4D_{3/2}$–z $^4F_{3/2}$						
4c	9965.44	10031.93							
15	9957.29	10040.14	b $^4F_{3/2}$–z $^4G_{3/2}$						
25	9912.26	10085.75	a $^4D_{1/2}$–z $^4F_{3/2}$						
20	9910.35	10087.70							
5	9896.6	10101.7	183$_{3/2}$–y $^2G_{7/2}$						
4c	9890.09	10108.36							
2	9815.56	10185.11	a $^2D_{3/2}$–z $^4D_{3/2}$?						
4	9677.5	10330.4	b $^4F_{9/2}$–z $^4G_{9/2}$						
80	9676.75	10331.22	a $^4D_{1/2}$–z $^4F_{3/2}$						
3	9669.8	10338.6							
12	9650.97	10358.81	b $^4F_{1/2}$–z $^4G_{3/2}$						
80c	9631.11	10380.18	a $^4D_{3/2}$–z $^4F_{5/2}$						
100c	9626.88	10384.74	a $^4D_{5/2}$–z $^4F_{5/2}$						
10	9620.96	10391.12	b $^4F_{5/2}$–z $^4G_{5/2}$						
2	9614.7	10397.87	b $^2G_{7/2}$–y $^2G_{9/2}$						
6c	9598.72	10415.20							
60c	9595.06	10419.17	a $^4D_{3/2}$–z $^4F_{3/2}$						
8c	9549.13	10469.29	b $^4D_{5/2}$–y $^4F_{5/2}$						
3	9518.30	10503.20	b $^2H_{9/2}$–z $^2G_{7/2}$						
5	9474.57	10551.67	b $^4F_{7/2}$–z $^4F_{5/2}$						
4	9472.02	10554.52	b $^4F_{9/2}$–z $^4G_{7/2}$						
6	9470.93	10555.73							
8h	9438.7	10591.8	b $^4F_{3/2}$–z $^4F_{3/2}$						
8c	9435.48	10595.39							
4	9412.39	10621.38	b $^4D_{1/2}$–y $^4F_{3/2}$						
20	9406.60	10625.66	a $^4D_{3/2}$–z $^4F_{3/2}$						
4	9393.56	10642.67							

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm⁻¹	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
10	9353.17	10688.63	a $^3P_{1/2}$—z $^4P_{3/2}$						
4	9344.4	10698.7	b $^4D_{3/2}$—y $^4F_{3/2}$						
3	9341.52	10701.96	b $^4F_{3/2}$—z $^4P_{3/2}$						
6c	9323.54	10722.60	a $^4D_{1/2}$—z $^4F_{3/2}$						
10	9209.2	10750.7							
10c	9240.9	10818.5							
15	9197.60	10869.42	b $^4F_{3/2}$—z $^4F_{3/2}$						
20	9186.96	10882.01	b $^4F_{3/2}$—z $^4F_{5/2}$						
50c	9141.31	10936.35	b $^2G_{7/2}$—y $^2G_{7/2}$						
10c	9129.44	10950.57	a $^4D_{3/2}$—z $^6D_{3/2}$						
10	9125.25	10955.60	b $^4F_{1/2}$—z $^4F_{3/2}$						
2	9123.60	10957.58	b $^2H_{9/2}$—y $^2G_{7/2}$						
7	9117.68	10964.70							
7	9084.91	11004.25	a $^4G_{3/2}$—z $^4G_{3/2}$						
4c	9066.54	11026.54	b $^2H_{9/2}$—y $^2G_{7/2}$						
20c	9061.43	11032.76	b $^4F_{3/2}$—z $^4F_{5/2}$						
5	9042.23	11056.19	b $^2G_{7/2}$—z $^6D_{3/2}$						
2	9041.27	11057.36	b $^4F_{5/2}$—z $^4G_{5/2}$						
8	9039.18	11059.92	a $^4D_{1/2}$—z $^6D_{3/2}$						
7	9011.74	11093.59							
4	8983.15	11128.90							
20c	8967.76	11148.00							
20c	8959.75	11157.96	b $^4D_{3/2}$—y $^4F_{5/2}$						
6	8933.43	11190.84	a $^4G_{5/2}$—z $^4G_{5/2}$						
3	8930.70	11194.26							
4c	8915.76	11213.02	a $^4D_{3/2}$—z $^6D_{5/2}$						
20	8905.78	11225.58	a $^4G_{1/2}$—z $^4F_{3/2}$						
6	8897.5	11236.0	b $^2G_{9/2}$—z $^4H_{7/2}$						
4	8896.4	11237.4	b $^4F_{1/2}$—z $^2D_{3/2}$						
100c	8815.56	11340.47	{a $^4D_{3/2}$—z $^4D_{3/2}$ {a $^4D_{3/2}$—z $^4D_{1/2}$						
7	8799.76	11360.83	b $^4F_{9/2}$—z $^4F_{9/2}$						
3	8798.22	11362.82							
7c	8769.57	11399.94	a $^4G_{3/2}$—z $^4G_{3/2}$						
12	8767.97	11402.02	a $^4D_{1/2}$—z $^4D_{3/2}$						
20	8740.96	11437.25	a $^4G_{3/2}$—z $^4F_{3/2}$						
4	8717.09	11468.57							
40c	8697.55	11494.34	a $^4G_{3/2}$—z $^4F_{5/2}$						
2	8695.10	11497.58	b $^4D_{1/2}$—y $^4D_{1/2}$						
2h	8681.94	11515.00	b $^2G_{7/2}$—y $^2G_{7/2}$						
30c	8614.45	11605.22	{b $^2H_{9/2}$—y $^2G_{7/2}$ {a $^2G_{7/2}$—z $^4F_{9/2}$	6		0.27	1.11	1.09	(1.12)
30c	8575.86	11657.44	a $^4G_{5/2}$—z $^4F_{5/2}$	4		0	1.20	1.22	(1.24)
30c	8560.54	11678.30	a $^4D_{1/2}$—z $^4D_{1/2}$	6		0	1.22	(1.20)	1.24
20c	8547.25	11696.46	a $^4D_{5/2}$—z $^4D_{5/2}$	••		0	0	0	0
30	8526.99	11734.25	a $^4H_{7/2}$—z $^4G_{5/2}$	5		w	0.90	(0.69)	0.61
150c	8475.98	11794.81	a $^4D_{3/2}$—z $^4D_{3/2}$	6		w	1.38	(1.36)	1.40
25c	8439.76	11845.43	a $^4G_{5/2}$—z $^4G_{5/2}$	5		0	1.41	(1.23)	1.29
5h	8434.31	11853.08							
4h	8433.90	11853.66							
4	8417.07	11877.36				0	1.40		
5	8414.72	11880.67	a $^2P_{3/2}$—z $^4P_{3/2}$	6	1.78	0.89	1.55	0.66	2.44
15c	8406.23	11892.67	b $^4D_{3/2}$—y $^4D_{3/2}$	6	0.15	0.38	1.35	1.42	1.27
3h	8389.36	11916.59							
4h	8387.88	11918.69							
4h	8371.39	11942.17							
20	8350.06	11972.72	a $^4D_{5/2}$—z $^4D_{5/2}$	5	1.20	0.60	1.37	0.07	1.27
60	8346.07	11978.40	a $^4H_{9/2}$—z $^4G_{7/2}$	7b	0	0	0.96	(0.96)	0.96
100c	8320.93	12014.59	a $^4D_{3/2}$—z $^4D_{1/2}$	6		w	1.43	(1.42)	1.44
3/I	8293.64	12054.12	b $^4F_{5/2}$—y $^4F_{5/2}$						
1h	8277.98	12076.93	b $^4D_{3/2}$—y $^4D_{3/2}$						
1h	8277.39	12077.79	b $^4F_{9/2}$—y $^4F_{9/2}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ_{air} A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
3	8275.25	12080.91	$b\ {}^4F_{3/2}-z\ {}^2D^o_{5/2}$						
4h	8262.41	12099.60	$a\ {}^4H_{13/2}-z\ {}^4G^o_{11/2}$						
50c	8240.00	12132.59	$a\ {}^4D_{7/2}-z\ {}^4D^o_{5/2}$	5			sh	1.55	(1.20)
3h	8236.80	12137.30	$b\ {}^4D_{5/2}-y\ {}^4D^o_{5/2}$						
3h	8228.96	12148.87	$a\ {}^4G_{9/2}-z\ {}^4F^o_{9/2}$						
3h	8226.08	12153.12							
3h	8211.23	12175.10							
5	8205.38	12183.78							
2*Hl*	8202.67	12187.80	$a\ {}^4G_{9/2}-y\ {}^6F^o_{7/2}$?						
4	8190.64	12205.72	$b\ {}^4D_{3/2}-z\ {}^4D^o_{3/2}$						
3h	8189.33	12207.66	$a\ {}^2P_{1/2}-z\ {}^2D^o_{3/2}$						
5	8176.22	12227.23	$b\ {}^4D_{1/2}-z\ {}^4D^o_{3/2}$						
6	8173.03	12232.01				0	0.83		
3	8168.48	12238.82							
3h	8157.00	12256.04	$a\ {}^2P_{1/2}-z\ {}^4F^o_{3/2}$						
2h	8154.42	12259.92	$a\ {}^4G_{7/2}-y\ {}^6F^o_{5/2}$						
80	8135.20	12288.89	$a\ {}^4H_{9/2}-z\ {}^4G^o_{9/2}$	4		0	1.06	(1.12)	1.14
6h	8118.67	12313.91							
7*w*	8118.17	12314.66	$b\ {}^4D_{3/2}-y\ {}^4D^o_{3/2}$	6		*w*	1.41	1.41	(1.42)
2h	8107.85	12330.34	$b\ {}^4D_{3/2}-z\ {}^2F^o_{5/2}$						
4	8085.17	12364.93							
2	8084.27	12366.30	$a\ {}^2P_{1/2}-z\ {}^4P^o_{3/2}$						
4h	8037.74	12437.89	$b\ {}^4P_{3/2}-y\ {}^4D^o_{3/2}$						
5	8036.08	12440.46							
10	8028.74	12451.83	$b\ {}^4D_{1/2}-z\ {}^2P^o_{1/2}$						
4h	8024.74	12458.04	$b\ {}^4D_{5/2}-z\ {}^2P^o_{3/2}$						
50c	8017.67	12469.03	$a\ {}^4D_{3/2}-z\ {}^4D^o_{3/2}$	5		0	1.45*	(1.36)	1.49
5h	8017.23	12469.71							
3h	8010.85	12479.64	$b\ {}^4D_{1/2}-z\ {}^2P^o_{1/2}$						
3h	8007.80	12484.86	$b\ {}^4F_{1/2}-z\ {}^2D^o_{3/2}$						
8	8002.46	12492.73	$a\ {}^4H_{11/2}-z\ {}^4G^o_{11/2}$						
3h	7997.81	12499.99							
3h	7993.74	12506.35	$b\ {}^4P_{1/2}-y\ {}^4D^o_{3/2}$						
4	7979.99	12527.90	$b\ {}^4P_{3/2}-z\ {}^4D^o_{3/2}$						
10	7954.76	12567.64	$a\ {}^2D_{1/2}-z\ {}^4P^o_{1/2}$	4	1.53	.77	0.20	0.97	2.50
20	7938.90	12592.74	$a\ {}^2P_{1/2}-z\ {}^2S^o_{1/2}$	4	1.00	0.51	0.68	1.18	2.18
3h	7922.78	12618.37	$b\ {}^4D_{5/2}-z\ {}^4D^o_{5/2}$						
3	7909.36	12639.78	$b\ {}^4D_{1/2}-z\ {}^4D^o_{1/2}$						
4h	7902.14	12651.32	$a\ {}^4H_{13/2}-z\ {}^4F^o_{9/2}$						
10*Hw*	7898.88	12656.55							
1	7892.56	12666.68	$a\ {}^2P_{1/2}-y\ {}^6F^o_{3/2}$						
60	7885.30	12678.34	$a\ {}^4H_{11/2}-z\ {}^4G^o_{11/2}$	4		0	1.04	(1.22)	1.25
2h	7881.05	12685.18	$a\ {}^2G_{7/2}-z\ {}^4D^o_{5/2}$						
50c	7873.40	12697.51	$b\ {}^4P_{3/2}-y\ {}^4D^o_{5/2}$	4		0	1.30	1.52	(1.42)
10	7862.66	12714.85	$b\ {}^4P_{3/2}-27^6b_{5/2}$	6	0.14	0.34	1.36*	1.51	(1.37)
15	7856.05	12725.55	$b\ {}^4P_{1/2}-y\ {}^4D^o_{1/2}$						
5	7838.01	12754.84	$a\ {}^4G_{5/2}-z\ {}^4D^o_{5/2}$						
8	7829.12	12769.32	$\begin{cases} a\ {}^2D_{3/2}-z\ {}^2P^o_{3/2} \\ b\ {}^4D_{1/2}-z\ {}^4S^o_{3/2} \end{cases}$						
10	7787.06	12838.26				0.26	1.14		
5h	7772.11	12862.96							
8	7761.37	12880.78	$a\ {}^2P_{3/2}-z\ {}^4P^o_{3/2}$						
8	7758.33	12885.83							
30	7757.29	12887.56	$y\ {}^6F^o_{5/2}-e\ {}^6D_{3/2}$	4		*w*	1.00	(1.45)	1.53
10	7750.92	12898.15	$b\ {}^4P_{3/2}-z\ {}^2F^o_{5/2}$						
3	7748.53	12902.13							
10*w*	7746.92	12904.81							
6c	7735.85	12923.27	$b\ {}^4P_{5/2}-z\ {}^4D^o_{5/2}$						
3	7730.25	12932.64							
100	7726.67	12938.63	$a\ {}^6S_{5/2}-z\ {}^6P^o_{5/2}$	4	0.38	0.19	1.41	1.98	2.36
3	7724.01	12943.09							

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm⁻¹	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
4h	7716.83	12955.13	$a\ {}^4H_{11/2}-z\ {}^4G_{9/2}$						
5	7707.39	12971.00	$a\ {}^4H_{11/2}-z\ {}^4F_{9/2}$						
10w	7703.29	12977.90	$y\ {}^6F_{9/2}-e\ {}^6D_{9/2}$	4		*Hw*	0.92	(1.43)	1.58
3h	7694.37	12992.94							
3h	7686.50	13006.25	$a\ {}^2D_{3/2}-z\ {}^4F_{3/2}$ $b\ {}^4D_{1/2}-y\ {}^4F_{3/2}$						
4h	7678.34	13020.07	$b\ {}^4F_{3/2}-y\ {}^4F_{3/2}$						
3h	7669.13	13035.71	$z\ {}^6P_{3/2}-e\ {}^6D_{1/2}$						
10Hw	7662.74	13046.58							
10	7661.62	13048.49							
5h	7660.32	13050.70							
12	7659.02	13052.91							
5Hw	7649.69	13068.83	$b\ {}^2G_{7/2}-z\ {}^4F_{5/2}$						
3H	7648.46	13070.93	$a\ {}^4P_{3/2}-z\ {}^4F_{5/2}$						
20w	7647.60	13072.40	$y\ {}^6F_{11/2}-e\ {}^6D_{9/2}$	4		*Hw*	0.68	(1.38)	1.66
10	7644.15	13078.31	$b\ {}^4F_{5/2}-y\ {}^4F_{5/2}$						
1h	7641.77	13082.38	$b\ {}^4D_{3/2}-z\ {}^4D_{3/2}$						
5c	7640.72	13084.17	$b\ {}^4P_{3/2}-z\ {}^2D_{3/2}$						
12	7639.82	13085.72				0.25	0.89		
15Hc	7638.15	13088.58	$b\ {}^4P_{3/2}-y\ {}^4D_{3/2}$						
10	7628.16	13105.72							
4	7625.57	13110.17	$b\ {}^4D_{1/2}-z\ {}^4D_{1/2}$						
6	7621.14	13117.79	$a\ {}^2P_{3/2}-z\ {}^4F_{3/2}$						
4h	7615.88	13126.85	$z\ {}^6P_{1/2}-e\ {}^6D_{3/2}$						
5c	7603.40	13148.40	$b\ {}^4P_{1/2}-y\ {}^4D_{1/2}$	4	0.36	0.18	0.56°	1.68	(1.32)
1h	7595.06	13162.83	$b\ {}^4D_{3/2}-y\ {}^4F_{3/2}$						
2h	7593.63	13165.31							
20bl	7585.29	13179.79	$b\ {}^4P_{3/2}-z\ {}^4D_{1/2}$	4		0	1.66	1.53	(1.44)
8	7584.07	13181.91	$y\ {}^6F_{1/2}-e\ {}^6D_{1/2}$						
20	7583.22	13183.39	$b\ {}^4F_{1/2}-y\ {}^4F_{3/2}$	6	0.12	0.43	1.29°	(1.12)	1.24
30D	7574.57	13198.44	$a\ {}^6S_{5/2}-z\ {}^6P_{3/2}$	6	0.11	0.27	1.93	1.99	1.88
10	7551.96	13237.96	$b\ {}^4F_{3/2}-y\ {}^4F_{1/2}$						
12h	7547.71	13245.41	$y\ {}^6F_{1/2}-e\ {}^6D_{3/2}$	4	2.10	1.05	--	(1.06)	3.16
4h	7543.38	13253.01	$b\ {}^4D_{3/2}-z\ {}^2F_{5/2}$						
4	7540.18	13258.64	$a\ {}^4H_{9/2}-z\ {}^4F_{7/2}$						
10	7535.36	13267.12	$b\ {}^4D_{3/2}-z\ {}^4D_{3/2}$						
12h	7532.08	13272.90	$z\ {}^6P_{1/2}-e\ {}^6D_{3/2}$	6	0.12	0.41	1.61	1.68	1.56
6	7523.34	13288.31	$a\ {}^2D_{3/2}-z\ {}^2D_{3/2}$						
50wc	7519.77	13294.62	$b\ {}^4F_{3/2}-y\ {}^4F_{3/2}$	6	0.08	0.35	1.29	1.25	1.33
4	7517.51	13298.62							
8	7517.14	13299.28	$z\ {}^6P_{1/2}-e\ {}^6D_{1/2}$						
100	7515.92	13301.43	$a\ {}^4D_{1/2}-z\ {}^4P_{1/2}$	4	1.25	0.62	0.58	1.20	2.45
15w	7512.37	13307.72	$b\ {}^4P_{3/2}-y\ {}^4D_{1/2}$						
8w	7492.76	13342.55							
20	7478.20	13368.52	$b\ {}^4F_{1/2}-y\ {}^4F_{1/2}$	6	0.23	0.57	1.13°	(0.85)	1.08
4h	7460.82	13399.67	$a\ {}^2P_{3/2}-z\ {}^2D_{3/2}$						
10h	7459.08	13402.79	$b\ {}^4P_{1/2}-276_{3/2}$	4		*Hw*	0.87	1.70	(1.37)
2h	7458.29	13404.21							
12h	7456.31	13407.77	$y\ {}^6F_{1/2}-e\ {}^6D_{1/2}$	6	0.18	0.63	1.59°	(1.38)	1.86
12h	7452.88	13413.94	$y\ {}^6F_{1/2}-e\ {}^6D_{1/2}$	6	0.82	1.23	1.43	1.02	1.84
10h	7446.60	13425.26	$y\ {}^6F_{3/2}-e\ {}^6D_{3/2}$ $a\ {}^6S_{5/2}-y\ {}^6F_{3/2}$						
8h	7445.26	13427.67	$a\ {}^2F_{7/2}-y\ {}^2D_{3/2}$						
7	7436.99	13442.60							
7	7436.02	13444.36				*Hw*	0.69		
7	7435.37	13445.53	$y\ {}^6F_{3/2}-e\ {}^6D_{3/2}$						
7	7434.62	13446.89	$a\ {}^2D_{3/2}-z\ {}^4P_{3/2}$						
10	7430.12	13455.03	$b\ {}^4P_{1/2}-z\ {}^4D_{3/2}$ $a\ {}^2P_{1/2}-z\ {}^2D_{3/2}$						
12	7428.50	13457.97	$b\ {}^4F_{3/2}-y\ {}^4F_{5/2}$						
8	7426.06	13462.39	$a\ {}^4P_{3/2}-z\ {}^6F_{5/2}$ $a\ {}^4H_{9/2}-z\ {}^4F_{9/2}$						
4h	7425.26	13463.84							
12	7419.83	13473.69	$b\ {}^4F_{3/2}-y\ {}^4F_{3/2}$						

TABLE 4.—*First spectrum of columbium* (Cb 1)—Continued

Intensity Arc	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	θ_1	θ_2
1	2	3	4	5	6	7	7	8	10
8	7409.81	13491.91	$a\ ^5F_{1\frac{1}{2}}-z\ ^3G_{3\frac{1}{2}}$						
500	7372.51	13560.17	$a\ ^5S_{2\frac{1}{2}}-z\ ^5P_{1\frac{1}{2}}$	4	0.31	0.14	0.88	1.97	1.66
6A	7366.48	13571.27	$b\ ^5P_{1\frac{1}{2}}-y\ ^5P_{1\frac{1}{2}}$						
4	7362.10	13579.35							
100c	7353.17	13595.84	$a\ ^5D_{3\frac{1}{2}}-z\ ^5P_{2\frac{1}{2}}$	16	2.45	1.22	1.22	0	2.45
4A	7350.58	13600.63							
2A	7348.86	13603.81	$a\ ^5D_{2\frac{1}{2}}-z\ ^5G_{3\frac{1}{2}}$						
4	7340.26	13619.75							
10	7332.30	13634.54	$z\ ^5P_{2\frac{1}{2}}-e\ ^5D_{3\frac{1}{2}}$						
3	7331.44	13636.13	$b\ ^5P_{2\frac{1}{2}}-z\ ^5F_{1\frac{1}{2}}$						
30	7328.38	13641.83	$b\ ^5F_{1\frac{1}{2}}-y\ ^5F_{1\frac{1}{2}}$						
25A	7323.91	13650.14	$b\ ^5P_{1\frac{1}{2}}-z\ ^5D_{1\frac{1}{2}}$						
20w	7317.03	13662.99	$z\ ^5P_{1\frac{1}{2}}-e\ ^5D_{1\frac{1}{2}}$						
8A	7311.93	13672.52	$183_{3\frac{1}{2}}-z\ ^5G_{3\frac{1}{2}}$						
3	7300.69	13693.57	$a\ ^5G_{4\frac{1}{2}}-z\ ^5G_{3\frac{1}{2}}$						
3 H	7293.22	13707.59	$b\ ^5P_{1\frac{1}{2}}-z\ ^5P_{1\frac{1}{2}}$						
10	7276.76	13738.60	$a\ ^5F_{1\frac{1}{2}}-z\ ^5F_{1\frac{1}{2}}$						
10	7274.78	13742.34	$b\ ^5D_{1\frac{1}{2}}-z\ ^5D_{1\frac{1}{2}}$						
8A	7268.92	13753.42	$b\ ^5F_{2\frac{1}{2}}-y\ ^5P_{2\frac{1}{2}}$						
2A	7262.80	13765.01	$b\ ^3G_{4\frac{1}{2}}-z\ ^3G_{3\frac{1}{2}}$?						
15	7258.00	13772.40	$b\ ^5F_{1\frac{1}{2}}-y\ ^5F_{1\frac{1}{2}}$						
10	7256.19	13777.55	$a\ ^5D_{2\frac{1}{2}}-z\ ^5F_{1\frac{1}{2}}$						
12w	7253.19	13783.24							
40	7252.35	13784.81	$a\ ^5P_{2\frac{1}{2}}-z\ ^3S_{1\frac{1}{2}}$	6	1.48	0.74	1.39	0.65	2.13
8	7248.12	13792.89	$a\ ^5P_{2\frac{1}{2}}-z\ ^5F_{1\frac{1}{2}}$						
7	7244.55	13799.68	$a\ ^5P_{1\frac{1}{2}}-z\ ^5D_{1\frac{1}{2}}$						
7	7241.81	13804.90	$a\ ^3D_{1\frac{1}{2}}-z\ ^5F_{1\frac{1}{2}}$ $b\ ^5D_{3\frac{1}{2}}-z\ ^5H_{3\frac{1}{2}}$						
10A	7240.11	13808.14	$a\ ^5G_{4\frac{1}{2}}-y\ ^5F_{3\frac{1}{2}}$						
8A	7235.68	13816.60	$a\ ^3F_{2\frac{1}{2}}-z\ ^3G_{3\frac{1}{2}}$						
8H	7233.87	12820.06	$a\ ^3G_{3\frac{1}{2}}-z\ ^5G_{3\frac{1}{2}}$						
2	7221.07	13844.55	$a\ ^3F_{2\frac{1}{2}}-y\ ^5D_{2\frac{1}{2}}$						
2	7213.58	13858.93	$a\ ^3F_{2\frac{1}{2}}-z\ ^5F_{2\frac{1}{2}}$						
15c	7208.95	13867.83	$b\ ^5P_{1\frac{1}{2}}-z\ ^5D_{1\frac{1}{2}}$						
10c	7207.92	13869.80	$b\ ^5P_{2\frac{1}{2}}-y\ ^5P_{2\frac{1}{2}}$						
15	7191.38	13901.71							
8	7186.17	13911.79	$a\ ^5G_{3\frac{1}{2}}-y\ ^5F_{2\frac{1}{2}}$ $a\ ^3F_{2\frac{1}{2}}-z\ ^5D_{2\frac{1}{2}}$						
8A	7185.57	13912.95							
8A	7184.89	13914.27	$b\ ^5F_{3\frac{1}{2}}-z\ ^3G_{3\frac{1}{2}}$						
10w	7180.00	13923.74	$a\ ^5G_{3\frac{1}{2}}-y\ ^5F_{2\frac{1}{2}}$						
15w	7178.27	13927.10	$h\ ^5D_{3\frac{1}{2}}-z\ ^5D_{2\frac{1}{2}}$						
4	7172.98	13937.37	$a\ ^3H_{3\frac{1}{2}}-y\ ^5F_{2\frac{1}{2}}$ $b\ ^3G_{4\frac{1}{2}}-e\ ^5F_{3\frac{1}{2}}$						
4	7170.75	13941.71	$a\ ^5D_{1\frac{1}{2}}-z\ ^5G_{2\frac{1}{2}}$						
10w	7165.84	13951.26	$a\ ^5P_{2\frac{1}{2}}-z\ ^5F_{2\frac{1}{2}}$						
3	7163.92	13955.00	$a\ ^3F_{2\frac{1}{2}}-y\ ^5D_{1\frac{1}{2}}$						
100	7159.44	13963.73	$a\ ^5D_{2\frac{1}{2}}-z\ ^5P_{1\frac{1}{2}}$	4	0.23	0.12	1.00	1.35	1.59
10w	7151.45	13979.33	$a\ ^5D_{3\frac{1}{2}}-z\ ^5G_{3\frac{1}{2}}$						
8w	7146.19	13989.62	$b\ ^5D_{3\frac{1}{2}}-z\ ^5H_{3\frac{1}{2}}$						
4	7136.09	14009.42							
12	7130.06	14021.27	$b\ ^5F_{3\frac{1}{2}}-z\ ^5D_{2\frac{1}{2}}$						
40	7126.18	14028.90	$a\ ^5G_{3\frac{1}{2}}-y\ ^5F_{3\frac{1}{2}}$						
10	7122.96	14035.24				0	1.06		
10	7121.91	14037.31	$b\ ^5P_{2\frac{1}{2}}-z\ ^5D_{2\frac{1}{2}}$						
10	7121.25	14038.62	$a\ ^5P_{2\frac{1}{2}}-z\ ^5F_{1\frac{1}{2}}$? $a\ ^5P_{2\frac{1}{2}}-y\ ^5F_{2\frac{1}{2}}$?						
10	7120.66	14039.78							
15	7119.32	14042.42	$a\ ^5G_{3\frac{1}{2}}-y\ ^5F_{3\frac{1}{2}}$						
3A	7108.58	14063.63	$a\ ^5H_{4\frac{1}{2}}-y\ ^5F_{3\frac{1}{2}}$						
30w	7102.02	14076.62	$a\ ^5D_{3\frac{1}{2}}-z\ ^5F_{3\frac{1}{2}}$						
50c	7098.94	14082.73	$a\ ^5G_{4\frac{1}{2}}-y\ ^5F_{3\frac{1}{2}}$						
3	7091.30	14097.91	$b\ ^5F_{1\frac{1}{2}}-y\ ^5D_{2\frac{1}{2}}$?						
4	7090.73	14099.04	$a\ ^5F_{2\frac{1}{2}}-276_{2\frac{1}{2}}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
12	7075.24	14129.91	$a\ {}^4P_{1/2}-z\ {}^6F_{3/2}$						
3	7070.02	14140.34	$b\ {}^4F_{3/2}-y\ {}^6D_{3/2}$						
20	7066.42	14147.54	$a\ {}^4G_{3/2}-y\ {}^4F_{3/2}$						
1h	7063.49	14153.41	$b\ {}^4P_{1/2}-y\ {}^4P_{1/2}$						
2h	7059.17	14162.08	$b\ {}^4D_{3/2}-y\ {}^2D_{3/2}$						
12	7051.22	14178.04	$b\ {}^2G_{4/2}-z\ {}^2G_{3/2}$						
20w	7046.81	14186.92	$a\ {}^4D_{3/2}-z\ {}^4P_{3/2}$	4		sr	1.38	(1.42)	1.45
10	7038.06	14204.55	$b\ {}^4F_{3/2}-z\ {}^2G_{3/2}$						
6	7035.66	14209.40	$a\ {}^2F_{3/2}-276_{3/2}$						
20w	7023.48	14234.04	$b\ {}^4P_{1/2}-y\ {}^4P_{3/2}$	4		sr	1.34	1.78	(1.61)
5	7014.91	14251.43							
3h	7013.35	14254.60							
20w	7003.95	14273.73	$b\ {}^4F_{4/2}-y\ {}^6D_{3/2}$ $183_{3/2}-s\ {}^4F_{3/2}$						
3h	6999.73	14282.29	$a\ {}^2F_{3/2}-z\ {}^2F_{3/2}$						
20	6996.12	14289.70	$b\ {}^4P_{3/2}-z\ {}^2P_{3/2}$	4		0.56	0.88	2.58	(1.45)
100	6990.32	14301.56	$a\ {}^4D_{1/2}-z\ {}^4P_{1/2}$	6	0.398	0.606	1.405	1.206	1.604
6	6989.40	14303.44	$a\ {}^4G_{3/2}-y\ {}^4F_{3/2}$						
15	6986.09	14310.22	$b\ {}^4F_{3/2}-z\ {}^4D_{3/2}$						
3h	6978.40	14325.99	$a\ {}^4P_{1/2}-z\ {}^6D_{3/2}$						
6h	6975.05	14332.87				sr	1.51		
10h	6972.48	14338.15	$b\ {}^4P_{1/2}-z\ {}^4D_{3/2}$	4		sr	1.11	1.71	(1.47)
5h	6971.62	14339.92	$a\ {}^2F_{3/2}-y\ {}^2G_{3/2}$						
8w	6964.75	14354.06							
3h	6955.67	14372.80	$b\ {}^4P_{3/2}-z\ {}^4H_{3/2}$						
5H	6953.54	14377.20	$b\ {}^4F_{3/2}-y\ {}^4D_{3/2}$						
10	6946.08	14392.65	$a\ {}^2F_{3/2}-z\ {}^2F_{3/2}$	6		0.76	..	(0.86)	1.16
8	6940.92	14403.35							
3	6939.40	14406.50							
2h	6936.60	14412.31							
4	6928.35	14429.48	$b\ {}^4F_{3/2}-y\ {}^4D_{3/2}$						
60, V	6918.33	14450.38	$a\ {}^2F_{3/2}-y\ {}^2G_{3/2}$	5		sr	0.95	(0.86)	0.92
4	6911.15	14465.39	$b\ {}^2G_{4/2}-w\ {}^4G_{3/2}$						
4	6910.23	14467.31	$a\ {}^4F_{1/2}-z\ {}^2D_{3/2}$						
40, V	6906.06	14471.85	$a\ {}^2D_{1/2}-z\ {}^2S_{1/2}$	4	1.176	0.588	0.370	0.958	2.134
6	6906.60	14474.92	$a\ {}^4G_{4/2}-y\ {}^2D_{3/2}$?						
30r	6902.89	14482.70	$a\ {}^4D_{3/2}-z\ {}^2D_{3/2}$	5	0.46	0.23	2.00	(1.36)	0.90
6	6888.49	14512.97				sr	1.15		
15r	6886.32	14517.55	$a\ {}^4D_{3/2}-z\ {}^4F_{3/2}$						
2h	6884.98	14520.37	$b\ {}^4D_{3/2}-z\ {}^4F_{3/2}$						
10w	6879.90	14531.09	$a\ {}^4D_{3/2}-z\ {}^4F_{3/2}$						
4h	6878.66	14533.71							
5	6877.79	14535.55	$a\ {}^2D_{3/2}-z\ {}^2D_{3/2}$						
60, V	6876.36	14538.57	$a\ {}^4D_{1/2}-z\ {}^4F_{3/2}$	6	0.78	1.17	0.79	1.18	0.40
8h	6871.68	14548.48				sr	1.14		
15w	6870.92	14550.09							
5h	6861.82	14569.38	$b\ {}^2G_{4/2}-y\ {}^4F_{3/2}$						
8	6857.14	14579.32	$b\ {}^4F_{3/2}-z\ {}^4S_{3/2}$	4	0.81	0.40$_5$	1.37	2.62	(1.79)
20r	6849.33	14595.95	$a\ {}^4D_{3/2}-z\ {}^4P_{3/2}$	‡5	1.361	0.790	2.387	0.015	1.566
8w	6846.14	14602.75							
100, V	6828.11	14641.31	$a\ {}^4D_{3/2}-z\ {}^4P_{3/2}$	6	0.12	0.31	1.42	1.36	1.48
8w	6824.55	14648.95	$b\ {}^4P_{3/2}-y\ {}^6P_{3/2}$						
3	6803.44	14694.40	$b\ {}^4D_{3/2}-z\ {}^4F_{3/2}$ $b\ {}^4F_{3/2}-y\ {}^6D_{3/2}$?						
6h	6802.86	14695.65	$a\ {}^4G_{3/2}-y\ {}^6D_{3/2}$						
10h	6795.27	14712.07				sr	1.26		
3	6781.22	14742.55	$a\ {}^2P_{1/2}-y\ {}^4F_{3/2}$						
5h	6752.96	14804.20	$183_{3/2}-u\ {}^4F_{3/2}$						
8w	6745.44	14820.75	$a\ {}^4D_{1/2}-z\ {}^2D_{3/2}$?	6	0.31	0.16	1.32*	(1.20)	0.89
80, V	6739.88	14832.97	$a\ {}^4D_{3/2}-z\ {}^4F_{3/2}$	‡5	0.410	0.205	0.618	0.005	0.415
5	6738.96	14835.00	$b\ {}^4D_{3/2}-y\ {}^4G_{3/2}$						
8	6728.82	14857.35	$a\ {}^2G_{3/2}-z\ {}^4P_{3/2}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ_{air} A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
5h	6726.19	14863.16	$b\ ^3G_{3\frac{1}{2}}-v\ ^3F_{3\frac{1}{2}}$						
150, V	6723.62	14868.84	$a\ ^4D_{1\frac{1}{2}}-z\ ^4F_{1\frac{1}{2}}$	4	0.14	0.07	0.86	(1.20)	1.06
8	6721.98	14872.47	$a\ ^4P_{2\frac{1}{2}}-z\ ^4D_{2\frac{1}{2}}$	6	0.19	0.48		(1.60)	1.41
5	6719.27	14878.47	$a\ ^4G_{3\frac{1}{2}}-z\ ^3G_{3\frac{1}{2}}$						
3h	6718.93	14879.22	$b\ ^4D_{3\frac{1}{2}}-z\ ^4F_{3\frac{1}{2}}$						
6w	6717.56	14882.26				0.25	0.73		
10c	6709.89	14899.27	$a\ ^4D_{3\frac{1}{2}}-y\ ^4F_{3\frac{1}{2}}$						
60, V	6701.20	14918.59	$a\ ^3F_{2\frac{1}{2}}-y\ ^3G_{3\frac{1}{2}}$	4		0	1.08	(1.13)	1.11
4h	6699.82	14921.66							
5	6696.45	14929.17				w	1.03		
2	6683.75	14957.54							
2h	6681.36	14962.89	$a\ ^4G_{3\frac{1}{2}}-z\ ^3D_{3\frac{1}{2}}$?						
5H	6679.21	14967.71							
200c, V	6677.34	14971.90	$a\ ^4D_{2\frac{1}{2}}-z\ ^4F_{3\frac{1}{2}}$	4		0.06	1.00+	(1.36)	1.28
4	6666.24	14996.83	$b\ ^4D_{2\frac{1}{2}}-z\ ^4F_{2\frac{1}{2}}$						
300c, V	6660.84	15008.98	$a\ ^4D_{2\frac{1}{2}}-z\ ^4F_{1\frac{1}{2}}$	4		w	1.18+	(1.42)	1.23
10h	6655.90	15020.12	$a\ ^2F_{3\frac{1}{2}}-z\ ^2F_{3\frac{1}{2}}$						
4	6653.40	15025.77							
10H	6644.68	15045.49	$a\ ^4D_{3\frac{1}{2}}-z\ ^6P_{3\frac{1}{2}}$						
8	6626.98	15085.67	$a\ ^4P_{1\frac{1}{2}}-z\ ^4D_{1\frac{1}{2}}$	6	0.46	0.68		(1.72)	1.26
4h	6620.59	15100.23	$b\ ^2G_{4\frac{1}{2}}-u\ ^4F_{4\frac{1}{2}}$						
2	6618.35	15105.34	$b\ ^4F_{3\frac{1}{2}}-z\ ^2F_{3\frac{1}{2}}$						
6	6616.68	15109.15	$a\ ^4P_{2\frac{1}{2}}-z\ ^4D_{3\frac{1}{2}}$	6	2.62	1.31	1.31	2.62	0
20	6614.15	15114.93	$a\ ^4D_{3\frac{1}{2}}-z\ ^2D_{2\frac{1}{2}}$	‡5	0.860	0.431	1.336	0.045	0.969
10	6607.32	15130.56	$a\ ^2F_{2\frac{1}{2}}-z\ ^2F_{3\frac{1}{2}}$	5	0.28	0.14	1.77	(0.86)	1.14
10	6606.15	15133.24				w	0.91		
4h	6594.30	15160.43	$b\ ^4P_{2\frac{1}{2}}-z\ ^6S_{2\frac{1}{2}}$						
40c	6591.00	15168.02							
3	6586.79	15177.72	$a\ ^3G_{4\frac{1}{2}}-z\ ^4F_{4\frac{1}{2}}$						
5Hd	6580.50	15192.23	$a\ ^4H_{3\frac{1}{2}}-y\ ^4F_{3\frac{1}{2}}$?						
10	6574.74	15205.54	$a\ ^4D_{1\frac{1}{2}}-z\ ^2S_{1\frac{1}{2}}$	4	0.93	0.47	0.74	1.20	2.13
6	6556.93	15246.84					1.06		
8	6551.63	15259.17	$b\ ^2H_{4\frac{1}{2}}-w\ ^2F_{3\frac{1}{2}}$	4		0	1.01	1.05	(1.07)
4	6550.22	15262.45	$b\ ^4P_{2\frac{1}{2}}-z\ ^4F_{2\frac{1}{2}}$						
80c, V	6544.61	15275.54	$a\ ^4D_{2\frac{1}{2}}-z\ ^2D_{2\frac{1}{2}}$	5		0.09	1.71	(1.42)	1.30
6	6519.70	15333.90	$a\ ^2D_{1\frac{1}{2}}-z\ ^2D_{2\frac{1}{2}}$						
2	6500.83	15378.41	$b\ ^4F_{3\frac{1}{2}}-x\ ^4D_{3\frac{1}{2}}$?						
10	6497.85	15385.46	$\begin{cases} a\ ^4P_{2\frac{1}{2}}-z\ ^4D_{1\frac{1}{2}} \\ b\ ^2H_{4\frac{1}{2}}-z\ ^2G_{3\frac{1}{2}} \end{cases}$	4	1.36	0.66	0.55	2.63	1.27
4	6494.23	15394.04							
6h	6491.90	15399.56	$a\ ^2P_{1\frac{1}{2}}-y\ ^4D_{2\frac{1}{2}}$						
2H	6488.66	15407.25	$a\ ^4D_{2\frac{1}{2}}-z\ ^6P_{3\frac{1}{2}}$						
2	6482.73	15421.35	$a\ ^4G_{3\frac{1}{2}}-y\ ^2G_{3\frac{1}{2}}$?						
8	6464.32	15465.27				w	0.98		
10	6449.84	15499.98	$\begin{cases} a\ ^4D_{2\frac{1}{2}}-z\ ^6S_{2\frac{1}{2}} \\ a\ ^4D_{2\frac{1}{2}}-z\ ^6P_{2\frac{1}{2}} \end{cases}$	‡6	2.11	1.055	1.067	1.01	2.12
4	6437.76	15529.07							
30, V	6433.24	15539.98	$a\ ^4P_{1\frac{1}{2}}-z\ ^4D_{1\frac{1}{2}}$	4	0.31	0.16	0.93	1.71	1.40
30c, V	6430.47	15546.67	$a\ ^4P_{2\frac{1}{2}}-z\ ^4D_{2\frac{1}{2}}$	4	0.16	0.08	1.04	1.60	1.44
2c	6427.66	15553.47	$a\ ^4D_{1\frac{1}{2}}-z\ ^6P_{1\frac{1}{2}}$						
4	6422.06	15567.03	$b\ ^4F_{3\frac{1}{2}}-z\ ^4D_{3\frac{1}{2}}$						
2	6417.60	15577.85							
2	6375.93	15679.61	$a\ ^2G_{3\frac{1}{2}}-z\ ^4F_{3\frac{1}{2}}$						
2c	6355.56	15729.91	$a\ ^4D_{3\frac{1}{2}}-z\ ^2D_{2\frac{1}{2}}$						
6	6348.98	15746.22				0.00	0.91		
4	6346.24	15753.01	$a\ ^2H_{4\frac{1}{2}}-y\ ^2G_{4\frac{1}{2}}$	5		0	0.97	(0.93)	0.91
3h	6334.10	15783.21							
4	6325.78	15803.97	$a\ ^2P_{2\frac{1}{2}}-y\ ^4F_{3\frac{1}{2}}$	4	0.17	0.09	0.42	0.67	(0.50)
5c	6312.16	15838.07	$a\ ^4G_{3\frac{1}{2}}-z\ ^6D_{3\frac{1}{2}}$						
4c	6309.24	15845.40				w	1.13		
6c	6286.38	15903.02	$183_{4\frac{1}{2}}-w\ ^2G_{3\frac{1}{2}}$			w	0.85		
4	6275.41	15930.82	$a\ ^2H_{4\frac{1}{2}}-y\ ^2G_{3\frac{1}{2}}$	4		w	1.01	(1.10)	1.14

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm⁻¹	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	7	8	10
8c	6260.77	15968.07	$b\ ^3G_{4\frac{1}{2}}-z\ ^3H_{5\frac{1}{2}}$	4		ur	0.82	1.01	(0.95)
4h	6257.38	15976.72							
20c, V	6251.76	15991.08	$183_{3\frac{1}{2}}-z\ ^3H_{3\frac{1}{2}}$			ur	1.18		
5h	6228.25	16051.44							
20c, V	6221.95	16067.70	$a\ ^4D_{1\frac{1}{2}}-z\ ^3D_{1\frac{1}{2}}$	5		ur	1.33	(1.20)	1.27
5h	6219.59	16073.79				ur	1.32		
2h	6218.44	16076.06	$a\ ^4G_{4\frac{1}{2}}-y\ ^3G_{5\frac{1}{2}}$						
8, V	6213.06	16090.69	$b\ ^4D_{3\frac{1}{2}}-w\ ^4F_{4\frac{1}{2}}$	5	0.47	0.24	0.73	0.03	0.50
6	6204.75	16112.24	$b\ ^4D_{1\frac{1}{2}}-w\ ^4F_{1\frac{1}{2}}$	6	0.70	1.05	0.88	1.20	(0.50)
12, V	6164.30	16217.96	$a\ ^3F_{3\frac{1}{2}}-y\ ^3D_{3\frac{1}{2}}$	5		ur	0.90	(0.86)	0.81
10c, V	6148.11	16260.67	$a\ ^3F_{3\frac{1}{2}}-y\ ^3D_{2\frac{1}{2}}$	4	0.20	0.13	0.62	1.12	(1.32)
7c	6142.53	16275.44	$b\ ^4P_{2\frac{1}{2}}-y\ ^4D_{1\frac{1}{2}}$	4	0.41	0.20	0.93	1.55	1.96
7c	6128.68	16312.22				ur	1.04		
4c	6118.10	16340.43	$b\ ^4D_{2\frac{1}{2}}-v\ ^4F_{3\frac{1}{2}}$						
6	6110.94	16359.58				0.56	1.04		
9	6107.69	16368.28	$b\ ^4D_{1\frac{1}{2}}-v\ ^4F_{1\frac{1}{2}}$	4			0.80	1.22	(1.05)
2	6105.30	16374.69	$a\ ^3F_{3\frac{1}{2}}-z\ ^4F_{3\frac{1}{2}}$						
4c	6103.49	16379.54	$b\ ^3G_{4\frac{1}{2}}-z\ ^3H_{4\frac{1}{2}}$						
6	6083.55	16433.23	$a\ ^3H_{4\frac{1}{2}}-z\ ^3F_{3\frac{1}{2}}$	4		ur	0.26	(0.93)	1.12
4	6067.81	16475.86	$a\ ^3D_{3\frac{1}{2}}-z\ ^3D_{2\frac{1}{2}}$	4		0	0.81	(1.21)	1.47
12c	6056.64	16506.25	$b\ ^4D_{2\frac{1}{2}}-v\ ^4F_{2\frac{1}{2}}$ $183_{2\frac{1}{2}}-z\ ^3H_{3\frac{1}{2}}$	4		ur	1.04	1.46	(1.34)
1	6052.59	16517.29	$b\ ^4F_{3\frac{1}{2}}-x\ D_{3\frac{1}{2}}$						
10c	6048.71	16527.88	$b\ ^3H_{4\frac{1}{2}}-z\ ^3H_{4}$	6		0.22	0.97	0.99	0.95
2h	6047.46	16531.30	$a\ ^4G_{3\frac{1}{2}}-z\ ^4D_{2\frac{1}{2}}$						
20, V	6045.49	16536.69	$b\ ^4F_{3\frac{1}{2}}-z\ ^4H_{3\frac{1}{2}}$	4		ur	0.60	(1.12)	1.00
4	6041.96	16546.35	$b\ ^4D_{2\frac{1}{2}}-w\ ^4F_{1\frac{1}{2}}$						
10, V	6031.83	16574.14	$b\ ^4D_{1\frac{1}{2}}-w\ ^4F_{2\frac{1}{2}}$ $a\ ^6S_{2\frac{1}{2}}-z\ ^5P_{1\frac{1}{2}}$	4			0.71	1.19	(1.00)
12, V	6029.74	16579.88	$b\ ^4F_{3\frac{1}{2}}-z\ ^4H_{3\frac{1}{2}}$	5		0	0.93	(0.85)	0.89
5c	6028.73	16582.66	$a\ ^3F_{3\frac{1}{2}}-z\ ^4F_{4\frac{1}{2}}$						
1	6022.50	16599.81	$b\ ^3H_{4\frac{1}{2}}-w\ ^3G_{5\frac{1}{2}}$						
50c, V	5997.86	16668.01	$a\ ^4D_{3\frac{1}{2}}-y\ ^4F_{4\frac{1}{2}}$	6		0.79	1.33	1.44	1.21
5	5986.61	16699.33	$a\ ^3D_{2\frac{1}{2}}-y\ ^4D_{1\frac{1}{2}}$	4		ur	1.12	(1.21)	1.27
20, V	5986.08	16700.81	$b\ ^4F_{4\frac{1}{2}}-z\ ^4H_{5\frac{1}{2}}$	4		0.21_5	0.76+	(1.22)	1.14
100, IV?	5983.21	16708.82	$a\ ^4P_{1\frac{1}{2}}-z\ ^4P_{0\frac{1}{2}}$	4	0.75	0.38	1.35	1.72	2.47
5c	5971.25	16742.28					1.35		
4c	5965.36	16758.82	$b\ ^3H_{5\frac{1}{2}}-w\ ^3G_{5\frac{1}{2}}$	4		ur	0.70	1.03	(1.10)
1	5964.56	16761.06	$a\ ^3P_{1\frac{1}{2}}-z\ ^4D_{1\frac{1}{2}}$						
15, V	5957.69	16780.39	$b\ ^4F_{3\frac{1}{2}}-y\ ^4G_{4\frac{1}{2}}$	6	0.11	0.34	1.07	(1.12)	1.01
4	5949.90	16802.36	$b\ ^3G_{4\frac{1}{2}}-z\ ^3H_{5\frac{1}{2}}$	5		ur	1.10	0.99	(1.01)
2	5938.62	16834.28	$a\ ^4G_{3\frac{1}{2}}-z\ ^4H_{3\frac{1}{2}}$						
15c, V	5934.15	16846.96	$b\ ^3H_{4\frac{1}{2}}-z\ ^3H_{4}$	5		ur	1.52	1.00	(1.08)
12c, V	5928.234	16863.77	$a\ ^6S_{2\frac{1}{2}}-z\ ^6S_{1\frac{1}{2}}$						
10	5927.40	16866.14	$b\ ^4D_{2\frac{1}{2}}-w\ ^4F_{2\frac{1}{2}}$	4	0.23	0.12	0.72*	1.43	(1.20)
2h	5924.27	16875.05	$a\ ^4H_{3\frac{1}{2}}-z\ ^3F_{3\frac{1}{2}}$						
1h	5920.16	16886.76	$a\ ^4D_{3\frac{1}{2}}-y\ ^4F_{3\frac{1}{2}}$						
2h	5910.55	16914.22	$a\ ^4G_{4\frac{1}{2}}-z\ ^4H_{5\frac{1}{2}}$	5	0.34	0.17	1.55*	(1.23)	0.89
5	5904.48	16931.61	$b\ ^4D_{3\frac{1}{2}}-z\ ^3G_{4\frac{1}{2}}$	4	0.32	0.16	1.46*	1.41	(1.09)
20c, V	5903.80	16933.56	$a\ ^6S_{2\frac{1}{2}}-y\ ^6P_{1\frac{1}{2}}$						
200c, V	5900.59	16942.77	$a\ ^4D_{3\frac{1}{2}}-y\ ^4F_{4\frac{1}{2}}$	4		w	1.09+	(1.42)	1.35
3	5894.61	16959.96	$a\ ^3P_{1\frac{1}{2}}-y\ ^3P_{1\frac{1}{2}}$?						
15c, V	5893.43	16963.36	$b\ ^4P_{1\frac{1}{2}}-y\ ^4S_{1\frac{1}{2}}$	6	0.26	0.39	1.88	1.70	(1.96)
4	5885.94	16984.94	$b\ ^4D_{2\frac{1}{2}}-u\ ^4F_{3\frac{1}{2}}$	4	0.27	0.13	0.29	1.38_5	(1.11_5)
5	5878.97	17005.08	$b\ ^4F_{3\frac{1}{2}}-x\ ^4F_{3\frac{1}{2}}$						
20, V	5877.78	17006.52	$a\ ^4P_{0\frac{1}{2}}-z\ ^4P_{1\frac{1}{2}}$ $b\ ^4P_{2\frac{1}{2}}-u\ ^4F_{3\frac{1}{2}}$	6	0.18	0.09	2.55	2.64	2.46
8c	5876.30	17012.81	$183_{3\frac{1}{2}}-y\ ^3H_{4\frac{1}{2}}$	6		0.30	1.22−		
7c	5875.24	17015.88	$b\ ^4F_{4\frac{1}{2}}-x\ ^4F_{4\frac{1}{2}}$	5			1.35	(1.22)	1.19
40c, V	5874.68	17017.50	$a\ ^4D_{3\frac{1}{2}}-y\ ^4F_{3\frac{1}{2}}$	6	0.27	0.74	1.21	1.35	1.08
4d	5872.46	17023.93	$a\ ^4D_{3\frac{1}{2}}-y\ ^4D_{2\frac{1}{2}}$						
5	5868.89	17034.29	$b\ ^4D_{3\frac{1}{2}}-w\ ^4G_{4\frac{1}{2}}$	4	0.36	0.20	0.19	1.45	1.09
80, IV?	5866.45	17041.37	$a\ ^4P_{2\frac{1}{2}}-z\ ^4P_{1\frac{1}{2}}$	7b, 4		0	1.58	(1.60)	1.60

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ_{air} Å	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
6	5864.94	17045.76				ur	1.13		
2c	5863.21	17050.79	$b\ ^4D_{3\frac{1}{2}}-w\ ^4F_{3\frac{1}{2}}$						
4	5862.12	17053.96				ur	0.90		
5	5856.70	17069.74				0.54	1.15	1.07	1.22
6	5855.72	17072.60	$a\ ^4G_{3\frac{1}{2}}-z\ ^4D_{3\frac{1}{2}}$	6	0.15				
6	5852.79	17081.14				ur	1.03		
1	5851.94	17083.63	$b\ ^4F_{3\frac{1}{2}}-y\ ^2D_{2\frac{1}{2}}$						
2	5850.67	17087.33	$b\ ^4F_{3\frac{1}{2}}-x\ ^4F_{3\frac{1}{2}}$						
20c, V	5846.10	17100.69	$a\ ^6S_{2\frac{1}{2}}-y\ ^4P_{2\frac{1}{2}}$	6	0.38		1.78	1.97	1.89
30, V	5842.47	17111.32	$a\ ^4F_{4\frac{1}{2}}-z\ ^4F_{3\frac{1}{2}}$	4		ur	1.10	(1.33)	1.39
2	5839.17	17120.99	$b\ ^2G_{4\frac{1}{2}}-y\ ^4G_{3\frac{1}{2}}$						
100c, IV	5838.61	17122.63	$a\ ^4D_{3\frac{1}{2}}-y\ ^4F_{3\frac{1}{2}}$	4		ur	1.00	(1.36)	1.25
15c	5838.13	17124.04	$a\ ^3P_{1\frac{1}{2}}-z\ ^2P_{2\frac{1}{2}}$	5	0.30	0.20	1.35	1.16	0.76
40, V	5834.88	17133.57	$b\ ^4F_{4\frac{1}{2}}-z\ ^4F_{3\frac{1}{2}}$	6		0.12	1.23	1.24	1.21
2	5834.40	17134.98	$a\ ^4G_{3\frac{1}{2}}-z\ ^4H_{3\frac{1}{2}}$ $b\ ^4F_{3\frac{1}{2}}-y\ ^4G_{3\frac{1}{2}}$						
3	5825.41	17161.43	$a\ ^4G_{4\frac{1}{2}}-z\ ^4H_{3\frac{1}{2}}$	6	0.22	0.98	--	(1.23)	1.01
20c	5820.61	17175.58	$b\ ^2H_{4\frac{1}{2}}-z\ ^2I_{3\frac{1}{2}}$	4		w	0.64	1.02	(0.95)
80, V?	5819.415	17179.11	$a\ ^4G_{4\frac{1}{2}}-z\ ^4H_{3\frac{1}{2}}$ $b\ ^4F_{3\frac{1}{2}}-z\ ^4F_{3\frac{1}{2}}$	4		w	1.09+	(1.26)	1.23
15c	5815.316	17191.21	$a\ ^4G_{3\frac{1}{2}}-z\ ^4D_{2\frac{1}{2}}$	5	0.49	0.25	2.51	0.79	1.28
3	5811.89	17201.35	$a\ ^2F_{3\frac{1}{2}}-y\ ^2F_{2\frac{1}{2}}$	5		ur	1.58	(1.13)	0.95
5c	5810.68	17204.93							
1	5805.91	17219.07	$b\ ^2D_{2\frac{1}{2}}-w\ ^4G_{2\frac{1}{2}}$						
4c	5804.65	17222.80	$a\ ^4G_{3\frac{1}{2}}-y\ ^4G_{2\frac{1}{2}}$						
30d, V	5804.02	17224.67	$a\ ^4D_{1\frac{1}{2}}-y\ ^4F_{1\frac{1}{2}}$	6	0.74	1.08	0.83	1.20	0.46
1h	5801.78	17231.32	$a\ ^3P_{1\frac{1}{2}}-z\ ^4D_{1\frac{1}{2}}$						
2c	5801.01	17233.61	$a\ ^2G_{4\frac{1}{2}}-y\ ^4F_{3\frac{1}{2}}$						
20, V	5794.24	17253.75	$a\ ^4G_{2\frac{1}{2}}-z\ ^4H_{1\frac{1}{2}}$	5		w	1.18	(0.74)	0.87
7c	5789.78	17267.04	$a\ ^4G_{3\frac{1}{2}}-x\ ^4F_{2\frac{1}{2}}$	5		ur	1.40	(1.26)	1.20
80, III	5787.52	17273.78	$a\ ^4F_{3\frac{1}{2}}-z\ ^4F_{2\frac{1}{2}}$	4		w	0.96+	(1.24	1.34
8	5780.31	17295.32	$b\ ^4F_{2\frac{1}{2}}-x\ ^4F_{1\frac{1}{2}}$	6		0.38	1.05°	(0.85)	1.00
2	5779.78	17296.91	$b\ ^4F_{3\frac{1}{2}}-x\ ^4F_{2\frac{1}{2}}$	5		ur	1.61	(1.12)	1.23
20c, V	5776.07	17308.02	$a\ ^6S_{2\frac{1}{2}}-y\ ^6P_{1\frac{1}{2}}$	6		0.81°	1.88	1.99	(1.77)
4	5774.83	17311.74	$a\ ^5F_{3\frac{1}{2}}-y\ ^5F_{2\frac{1}{2}}$	6		0	0.83°	(0.86)	0.89
10c	5771.06	17323.05	$b\ ^4D_{2\frac{1}{2}}-y\ ^4F_{1\frac{1}{2}}$	4	0.24	0.12	0.47°	1.45	(1.31)
40, V	5764.98	17341.32	$a\ ^4G_{2\frac{1}{2}}-y\ ^4G_{1\frac{1}{2}}$	6		0.11	0.73	0.75	0.71
80, IV	5760.33	17355.31	$a\ ^4D_{1\frac{1}{2}}-y\ ^4F_{1\frac{1}{2}}$	4		w	0.91+	(1.20)	1.08
2c	5759.00	17359.32	$a\ ^2D_{2\frac{1}{2}}-y\ ^2D_{1\frac{1}{2}}$						
4h	5758.11	17362.01	$b\ ^2H_{4\frac{1}{2}}-z\ ^2H_{3\frac{1}{2}}$	6		ur	1.01	1.00	(1.01)
4c	5754.44	17373.08	$a\ ^2F_{2\frac{1}{2}}-y\ ^4P_{1\frac{1}{2}}$?			--	1.23		
3	5753.26	17376.64	$a\ ^2D_{2\frac{1}{2}}-276_{1\frac{1}{2}}$						
40, V	5751.43	17382.17	$a\ ^4G_{3\frac{1}{2}}-z\ ^4H_{3\frac{1}{2}}$	4		w	0.76	(1.08)	1.01
3c	5743.847	17405.12	$a\ ^4G_{4\frac{1}{2}}-y\ ^4G_{3\frac{1}{2}}$						
3	5743.384	17406.52	$b\ ^2H_{4\frac{1}{2}}-w\ ^2G_{3\frac{1}{2}}$	6		0.18	1.02	1.00	1.04
6	5738.19	17422.28				0	1.07		
7	5737.35	17424.83				0.12	--		
1c	5734.35	17433.94	$b\ ^4P_{2\frac{1}{2}}-w\ ^4F_{2\frac{1}{2}}$?			0.24	1.24		
80, III	5729.185	17449.66	$a\ ^4F_{2\frac{1}{2}}-z\ ^4F_{2\frac{1}{2}}$	4		w	0.85	(1.03)	1.15
9	5725.66	17460.40	$b\ ^2G_{4\frac{1}{2}}-y\ ^2H_{3\frac{1}{2}}$	6		d	0.96	0.97	0.95
4	5722.70	17469.44	$b\ ^4F_{2\frac{1}{2}}-x\ ^4F_{1\frac{1}{2}}$	5	0.32	0.16	2.03°	(0.85)	1.17
30, V	5716.34	17488.87	$a\ ^4G_{4\frac{1}{2}}-z\ ^4H_{3\frac{1}{2}}$	4		w	0.76+	(1.23)	1.15
6	5715.88	17491.20	$b\ ^4F_{1\frac{1}{2}}-z\ ^4F_{1\frac{1}{2}}$ $a\ ^4H_{4\frac{1}{2}}-z\ ^2F_{3\frac{1}{2}}$	7b		0	0.89	0.89	0.89
5c	5713.79	17496.68	$b\ ^2G_{4\frac{1}{2}}-z\ ^2H_{3\frac{1}{2}}$ $b\ ^2P_{1\frac{1}{2}}-y\ ^4F_{1\frac{1}{2}}$	4		0	0.68	0.86	(0.82)
2	5713.44	17497.75	$a\ ^2D_{1\frac{1}{2}}-y\ ^2D_{1\frac{1}{2}}$						
15	5709.33	17510.34	$a\ ^2F_{3\frac{1}{2}}-y\ ^2F_{2\frac{1}{2}}$ $a\ ^4F_{4\frac{1}{2}}-z\ ^2D_{2\frac{1}{2}}$	7b, 6		0	1.14	(1.13)	1.15
50, IV?	5706.47	17519.12	$a\ ^4D_{2\frac{1}{2}}-y\ ^4F_{2\frac{1}{2}}$	5	0.41	0.21	0.68	0.06	0.47
15	5706.16	17520.07	$b\ ^4D_{3\frac{1}{2}}-w\ ^4G_{2\frac{1}{2}}$	4		0.11	--	(1.43)	1.21
4	5698.01	17545.13	$a\ ^2D_{2\frac{1}{2}}-y\ ^4P_{1\frac{1}{2}}$	4	0.70	0.35	1.63	2.68	1.98
5	5697.89	17545.50	$b\ ^4P_{2\frac{1}{2}}-y\ ^4S_{1\frac{1}{2}}$	4	0.70	0.35	1.63	2.68	1.98
8	5693.07	17560.35	$a\ ^3P_{2\frac{1}{2}}-z\ ^3D_{1\frac{1}{2}}$	5	0.68	0.34	2.62	1.60	0.92
5c	5684.45	17586.98	$b\ ^2H_{4\frac{1}{2}}-z\ ^2H_{3\frac{1}{2}}$	6	0.22	1.01-	--	1.04	(0.82)

TABLE 4.—*First spectrum of columbium* (Cb 1)—Continued

Intensity Arc	λ_{air} A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
10	5677.453	17608.66	$a\ {}^4P_{3\frac{1}{2}}-z\ {}^4F_{3\frac{1}{2}}$	6	0.53	1.32	1.33	1.59	1.06
3	5675.942	17613.34	$a\ {}^3G_{3\frac{1}{2}}-y\ {}^4F_{3\frac{1}{2}}$						
80, IV	5671.90	17625.90	$a\ {}^4G_{3\frac{1}{2}}-y\ {}^4G_{3\frac{1}{2}}$	6	0.07	0.24	1.04	1.07	1.00
60, V	5671.09	17628.41	$a\ {}^6S_{2\frac{1}{2}}-y\ {}^6P_{3\frac{1}{2}}$	4	0.32	0.16	1.83*	2.02	(1.70)
9	5666.86	17641.57	$b\ {}^4D_{3\frac{1}{2}}-w\ {}^4F_{3\frac{1}{2}}$?			0.14	0.42		
120, III	5665.63	17645.40	$a\ {}^4G_{3\frac{1}{2}}-y\ {}^4G_{3\frac{1}{2}}$	7b, 6		0	1.26	(1.26)	1.26
100, III	5664.70	17648.30	$a\ {}^4F_{3\frac{1}{2}}-z\ {}^4F_{3\frac{1}{2}}$	5	0.772	0.386	0.785	0.399	−0.373
1	5662.04	17656.59	$a\ {}^2P_{2\frac{1}{2}}-y\ {}^4P_{1\frac{1}{2}}$						
5	5654.13	17681.29	$a\ {}^2D_{2\frac{1}{2}}-z\ {}^2P_{1\frac{1}{2}}$	4	0.23	0.12	0.76*	(1.21)	1.44
3c	5648.40	17699.23	$b\ {}^4F_{3\frac{1}{2}}-z\ {}^4F_{3\frac{1}{2}}$	5	0.605	0.303	2.038*	(0.402)	1.007
10	5645.20	17708.95	$a\ {}^4P_{1\frac{1}{2}}-z\ {}^4P_{1\frac{1}{2}}$	6	0.09	0.13	1.65	1.70	1.61
80, III	5642.10	17718.99	$a\ {}^4P_{2\frac{1}{2}}-z\ {}^4P_{1\frac{1}{2}}$	6	0.109	0.273	1.547	1.601	1.492
20c	5635.42	17739.99				w	1.08+		
2c	5633.64	17745.60							
6c	5629.81	17757.67	$a\ {}^4G_{3\frac{1}{2}}-y\ {}^2D_{2\frac{1}{2}}$						
40, V	5629.17	17759.69	$a\ {}^4G_{4\frac{1}{2}}-y\ {}^4G_{3\frac{1}{2}}$	6		u	1.24	1.21	(1.28)
10c	5628.25	17762.59	$a\ {}^4F_{3\frac{1}{2}}-z\ {}^4F_{2\frac{1}{2}}$	6	0.15	0.53	1.63*	(1.24)	1.39
1b	5619.78	17789.36	$a\ {}^4D_{2\frac{1}{2}}-y\ {}^4D_{1\frac{1}{2}}$	4			1.10b	(1.36)	1.24
3	5618.69	17792.82	$a\ {}^2P_{2\frac{1}{2}}-z\ {}^2P_{1\frac{1}{2}}$	5	0.77	0.38	1.85	0.70	1.47
7	5603.93	17839.68	$a\ {}^4F_{3\frac{1}{2}}-z\ {}^4D_{2\frac{1}{2}}$						
30, V	5603.51	17841.02	$a\ {}^4F_{2\frac{1}{2}}-z\ {}^4F_{1\frac{1}{2}}$	6	0.326	0.817	1.191	1.028	1.354
10c	5599.57	17853.57	$a\ {}^4D_{3\frac{1}{2}}-z\ {}^4G_{3\frac{1}{2}}$	4	0.37	0.20	--	(1.36)	0.99
5b	5596.87	17862.18	$a\ {}^4D_{2\frac{1}{2}}-y\ {}^4D_{2\frac{1}{2}}$	5		w	1.52	(1.42)	1.34
6c	5594.87	17868.57	$b\ {}^2H_{3\frac{1}{2}}-y\ {}^2H_{3\frac{1}{2}}$						
15c	5590.96	17881.10				w	1.15		
30, IV	5586.99	17893.77	$\begin{cases} a\ {}^4F_{3\frac{1}{2}}-z\ {}^4F_{3\frac{1}{2}} \\ a\ {}^4D_{3\frac{1}{2}}-y\ {}^4D_{3\frac{1}{2}} \end{cases}$	6	0.75	1.11	0.77	0.40	1.15
15, V	5578.28	17921.71	$a\ {}^4G_{4\frac{1}{2}}-z\ {}^4F_{3\frac{1}{2}}$	6		0.010	1.22	1.23	1.21
4c	5578.07	17922.38	$b\ {}^4P_{2\frac{1}{2}}-w\ {}^4F_{2\frac{1}{2}}$						
15c, V	5576.16	17928.52	$\begin{cases} a\ {}^4F_{4\frac{1}{2}}-z\ {}^4D_{3\frac{1}{2}} \\ b\ {}^4P_{1\frac{1}{2}}-u\ {}^4F_{1\frac{1}{2}} \end{cases}$						
2	5572.52	17940.23	$a\ {}^4D_{3\frac{1}{2}}-z\ {}^2D_{2\frac{1}{2}}$						
10c	5571.41	17943.81	$183_{3\frac{1}{2}}-z\ {}^2H_{3\frac{1}{2}}$				1.08±		
2	5566.12	17960.86	$z\ {}^2D_{2\frac{1}{2}}-e\ {}^2F_{3\frac{1}{2}}$						
10, V	5562.99	17970.97	$a\ {}^2D_{2\frac{1}{2}}-z\ {}^2S_{1\frac{1}{2}}$	4		--	0.31	1.20	(1.79)
4	5553.115	18002.92	$a\ {}^2G_{4\frac{1}{2}}-z\ {}^2G_{3\frac{1}{2}}$						
5	5552.23	18005.47	$a\ {}^4G_{3\frac{1}{2}}-y\ {}^2D_{2\frac{1}{2}}$						
60, V	5551.24	18008.68	$a\ {}^4P_{2\frac{1}{2}}-z\ {}^4P_{1\frac{1}{2}}$	4		0.52	1.08	2.64	1.60
2	5550.18	18012.44	$a\ {}^4D_{1\frac{1}{2}}-y\ {}^4D_{0\frac{1}{2}}$						
8c	5549.60	18014.33							
2c	5545.52	18027.58	$z\ {}^2D_{2\frac{1}{2}}-e\ {}^2F_{3\frac{1}{2}}$						
9	5541.461	18040.78	$a\ {}^2D_{2\frac{1}{2}}-y\ {}^2P_{1\frac{1}{2}}$						
3	5538.736	18049.66	$a\ {}^4P_{2\frac{1}{2}}-z\ {}^4F_{2\frac{1}{2}}$						
4	5532.89	18069.71	$a\ {}^2G_{3\frac{1}{2}}-z\ {}^2G_{3\frac{1}{2}}$						
30, IV?	5523.57	18099.22	$a\ {}^4D_{2\frac{1}{2}}-y\ {}^4D_{1\frac{1}{2}}$	6		0	1.41	(1.42)	1.40
3	5521.99	18104.72	$b\ {}^4P_{2\frac{1}{2}}-w\ {}^4D_{1\frac{1}{2}}$						
5	5517.39	18119.49				0	1.11		
15c, V	5512.81	18134.54							
4c	5511.22	18139.78							
2b	5510.69	18141.52	$a\ {}^4D_{3\frac{1}{2}}-z\ {}^2D_{2\frac{1}{2}}$						
7	5509.13	18146.66	$a\ {}^4F_{3\frac{1}{2}}-w\ {}^4F_{3\frac{1}{2}}$	5		--	1.40	(0.86)	0.50
1c	5506.74	18154.53	$\begin{cases} a\ {}^2H_{3\frac{1}{2}}-y\ {}^4G_{3\frac{1}{2}} \\ b\ {}^2H_{3\frac{1}{2}}-y\ {}^4G_{3\frac{1}{2}} \end{cases}$						
30c, III	5504.58	18161.66	$a\ {}^4F_{3\frac{1}{2}}-z\ {}^2D_{2\frac{1}{2}}$						
5	5501.739	18170.97				--	1.09b		
1	5500.53	18175.03	$a\ {}^2D_{2\frac{1}{2}}-276_{3\frac{1}{2}}$						
1	5499.87	18177.21	$a\ {}^2H_{4\frac{1}{2}}-z\ {}^4F_{3\frac{1}{2}}$						
7	5499.53	18178.33	$a\ {}^4F_{3\frac{1}{2}}-z\ {}^2D_{2\frac{1}{2}}$						
5b	5494.09	18196.33							
4	5491.062	18206.37	$z\ {}^2F_{3\frac{1}{2}}-e\ {}^2F_{3\frac{1}{2}}$						
1	5484.58	18227.86	$\begin{cases} a\ {}^4P_{1\frac{1}{2}}-z\ {}^2D_{1\frac{1}{2}} \\ a\ {}^4H_{4\frac{1}{2}}-z\ {}^4H_{3\frac{1}{2}} \end{cases}$						
8	5483.43	18231.54	$a\ {}^4D_{3\frac{1}{2}}-y\ {}^4D_{3\frac{1}{2}}$	6		--	1.25	(1.20)	1.30

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
5c	5483.08	18232.87							
15, V	5481.002	18239.79	$b\ ^3G_{4\frac{1}{2}}-z\ ^3H_{5\frac{1}{2}}$	5		...	1.65—	1.03	(1.14)
4c	5479.205	18245.77	$a\ ^4P_{2\frac{1}{2}}-z\ ^4F_{1\frac{1}{2}}$						
3	5478.74	18247.32	$z\ ^3D_{3\frac{1}{2}}-e\ ^3F_{2\frac{1}{2}}$						
1	5477.96	18249.91	$b\ ^4D_{2\frac{1}{2}}-v\ ^4D_{1\frac{1}{2}}$						
4c	5476.07	18256.21	$z^5D_{1\frac{1}{2}}-e\ ^4F_{1\frac{1}{2}}$ $b^4D_{2\frac{1}{2}}-v\ ^4D_{1\frac{1}{2}}$						
6c	5469.55	18277.97	$a^4F_{1\frac{1}{2}}-z\ ^4F_{1\frac{1}{2}}$ $a^4D_{1\frac{1}{2}}-x\ ^4D_{1\frac{1}{2}}$						
9	5468.10	18282.82	$z\ ^5D_{1\frac{1}{2}}-e\ ^4F_{2\frac{1}{2}}$						
3	5467.41	18285.13	$a\ ^4F_{1\frac{1}{2}}-z\ ^4F_{1\frac{1}{2}}$						
2	5466.90	18286.83	$a\ ^4H_{3\frac{1}{2}}-z\ ^4D_{1\frac{1}{2}}$						
1	5462.98	18299.96	$a^4G_{2\frac{1}{2}}-y\ ^4G_{1\frac{1}{2}}$ $a^4D_{1\frac{1}{2}}-z\ ^2F_{2\frac{1}{2}}$						
1	5462.03	18303.14	$a\ ^2F_{2\frac{1}{2}}-v\ ^4F_{1\frac{1}{2}}$						
4c	5460.935	18306.81	$a\ ^4D_{2\frac{1}{2}}-y\ ^4D_{1\frac{1}{2}}$						
10c	5458.043	18316.51	$a\ ^4D_{2\frac{1}{2}}-y\ ^4D_{1\frac{1}{2}}$	6		...	1.33h	(1.36)	1.30
3	5457.66	18317.79	$a\ ^4P_{1\frac{1}{2}}-z\ ^4P_{1\frac{1}{2}}$						
6	5456.19	18322.73	$z\ ^5D_{1\frac{1}{2}}-e\ ^4F_{1\frac{1}{2}}$						
2	5452.79	18334.15	$b\ ^4P_{1\frac{1}{2}}-w\ ^4D_{1\frac{1}{2}}$						
8	5448.306	18349.24	$a\ ^4H_{3\frac{1}{2}}-z\ ^4H_{3\frac{1}{2}}$						
4	5445.15	18359.88	$z\ ^5F_{1\frac{1}{2}}-e\ ^4F_{1\frac{1}{2}}$						
1c	5443.77	18364.53	$b\ ^4F_{1\frac{1}{2}}-x\ ^4G_{1\frac{1}{2}}$						
4c	5443.08	18366.86	$z\ ^5D_{1\frac{1}{2}}-e\ ^6F_{2\frac{1}{2}}$						
2c	5437.998	18384.02	$a\ ^4D_{1\frac{1}{2}}-z\ ^5D_{1\frac{1}{2}}$						
50, III	5437.265	18386.50	$a\ ^4P_{1\frac{1}{2}}-z\ ^4P_{1\frac{1}{2}}$	4	0.226	0.113	1.140	1.705	1.479
1	5434.46	18395.99	$a\ ^2F_{2\frac{1}{2}}-x\ ^2G_{1\frac{1}{2}}$						
2	5432.478	18402.70	$a\ ^2F_{2\frac{1}{2}}-v\ ^4F_{1\frac{1}{2}}$						
1	5431.77	18405.10	$b\ ^4D_{2\frac{1}{2}}-v\ ^4D_{1\frac{1}{2}}$						
12d, V	5431.25	18406.86	$a\ ^4F_{1\frac{1}{2}}-z\ ^4D_{1\frac{1}{2}}$	6	0.52	--	1.30	1.04	1.56
1	5427.82	18418.50	$a\ ^2F_{2\frac{1}{2}}-w\ ^2F_{1\frac{1}{2}}$						
20, IV	5422.42	18436.84	$a\ ^4H_{3\frac{1}{2}}-y\ ^4G_{1\frac{1}{2}}$	7b, 4		0	0.68	(0.69)	0.70
6c	5416.292	18457.70	$a\ ^2P_{1\frac{1}{2}}-y\ ^2D_{1\frac{1}{2}}$	5			1.57	1.20	(1.35)
8, V	5411.235	18477.95	$a\ ^4H_{4\frac{1}{2}}-z\ ^4H_{3\frac{1}{2}}$	6		0	1.00	(0.98)	1.02
2	5409.43	18481.11	$a\ ^4F_{1\frac{1}{2}}-z\ ^4D_{1\frac{1}{2}}$						
2	5404.427	18498.22	$a\ ^2F_{2\frac{1}{2}}-w\ ^4F_{1\frac{1}{2}}$						
2	5403.06	18502.90	$b\ ^4F_{2\frac{1}{2}}-x\ ^4G_{1\frac{1}{2}}$ $a\ ^2F_{2\frac{1}{2}}-u\ ^4F_{1\frac{1}{2}}$						
2	5402.49	18504.85	$a\ ^2G_{3\frac{1}{2}}-z\ ^2G_{3\frac{1}{2}}$						
1	5400.56	18511.46	$z\ ^5D_{1\frac{1}{2}}-e\ ^4F_{2\frac{1}{2}}$						
7c	5396.33	18525.97	$a\ ^4D_{2\frac{1}{2}}-y\ ^4D_{2\frac{1}{2}}$	5		0.59?	1.91	0.04	(1.29)
5	5395.849	18527.62	$a\ ^4P_{2\frac{1}{2}}-z\ ^2D_{2\frac{1}{2}}$						
2	5395.483	18528.88	$a\ ^2F_{2\frac{1}{2}}-w\ ^2F_{2\frac{1}{2}}$						
3c	5394.36	18532.74	$a\ ^2G_{3\frac{1}{2}}-y\ ^2D_{2\frac{1}{2}}$						
6	5388.300	18553.58	$a\ ^4D_{2\frac{1}{2}}-y\ ^4D_{1\frac{1}{2}}$	5		--	1.52h	(1.36)	1.43
1	5383.99	18568.44	$a\ ^2F_{2\frac{1}{2}}-v\ ^2F_{2\frac{1}{2}}$						
3	5382.842	18572.40	$a\ ^2F_{2\frac{1}{2}}-w\ ^2F_{2\frac{1}{2}}$						
10, III?	5381.326	18577.63	$a\ ^4P_{2\frac{1}{2}}-z\ ^4P_{2\frac{1}{2}}$ $b\ ^2G_{3\frac{1}{2}}-y\ ^2H_{3\frac{1}{2}}$	6	0.28	--	1.74	(1.00)	1.88
4c	5380.705	18579.77	$a\ ^2F_{2\frac{1}{2}}-z\ ^4D_{2\frac{1}{2}}$ $a\ ^4G_{3\frac{1}{2}}-y\ ^2F_{2\frac{1}{2}}$						
3c	5377.79	18589.84	$b\ ^4D_{2\frac{1}{2}}-v\ ^4D_{2\frac{1}{2}}$						
2	5376.722	18593.54	$z\ ^5F_{2\frac{1}{2}}-e\ ^6F_{2\frac{1}{2}}$						
3c	5375.916	18596.32	$a\ ^4H_{4\frac{1}{2}}-z\ ^4H_{4\frac{1}{2}}$						
8	5375.262	18598.59	$a\ ^4H_{4\frac{1}{2}}-z\ ^4H_{3\frac{1}{2}}$	6		0	1.14	(1.12)	1.16
4	5371.111	18612.96	$a\ ^4P_{1\frac{1}{2}}-z\ ^2S_{\frac{1}{2}}$	4			1.52	(1.72)	2.12
4	5368.390	18622.39	$a\ ^4F_{1\frac{1}{2}}-z\ ^4D_{1\frac{1}{2}}$						
1	5363.28	18640.14	$a\ ^2D_{1\frac{1}{2}}-z\ ^4D_{1\frac{1}{2}}$						
4	5363.075	18640.85	$a\ ^2F_{2\frac{1}{2}}-z\ ^4H_{3\frac{1}{2}}$						
6	5362.003	18644.58	$a^4D_{2\frac{1}{2}}-z\ ^6F_{2\frac{1}{2}}$ $z^6D_{3\frac{1}{2}}-e\ ^6F_{3\frac{1}{2}}$						
7	5359.183	18654.39	$a\ ^4D_{3\frac{1}{2}}-y\ ^4D_{2\frac{1}{2}}$	5		0?	1.49h	(1.20)	1.32

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
9	5355.083	18666.58	a $^4H_{3\frac{1}{2}}$—z $^4H_{3\frac{1}{2}}$	7b, 6		0	1.23	(1.22)	1.23
5	5355.300	18667.91	a $^4G_{4\frac{1}{2}}$—y $^3F_{3\frac{1}{2}}$ b $^3H_{4\frac{1}{2}}$—y $^3H_{3\frac{1}{2}}$						
3c	5355.086	18668.66	z $^6F_{3\frac{1}{2}}$—e $^6F_{3\frac{1}{2}}$						
5	5353.283	18674.95	z $^6D_{3\frac{1}{2}}$—e $^6F_{3\frac{1}{2}}$	4		--	1.08	(1.54)	1.46
6	5351.022	18682.84	a $^2F_{3\frac{1}{2}}$—w $^2F_{3\frac{1}{2}}$						
100c, III	5350.723	18683.88	a $^4F_{3\frac{1}{2}}$—z $^4D_{3\frac{1}{2}}$	4	0.16	0.08	0.83	1.23	1.39
2c	5345.55	18701.96	b $^4D_{3\frac{1}{2}}$—e $^4D_{3\frac{1}{2}}$						
200c, III	5344.160	18706.83	a $^4F_{4\frac{1}{2}}$—z $^4D_{3\frac{1}{2}}$	4	0.113	0.169	0.934	1.330	1.443
8c	5343.602	18708.78							
10, V	5340.793	18718.62	a $^4H_{4\frac{1}{2}}$—y $^4G_{5\frac{1}{2}}$	4		0	0.95	0.98	(1.00)
1	5339.89	18721.78	z $^6F_{3\frac{1}{2}}$—e $^6F_{3\frac{1}{2}}$						
4c	5337.572	18728.86	a $^6F_{3\frac{1}{2}}$—z $^6D_{3\frac{1}{2}}$						
6	5336.797	18732.63	a $^6D_{3\frac{1}{2}}$—z $^6F_{3\frac{1}{2}}$						
30, IV	5334.864	18739.42	a $^4D_{3\frac{1}{2}}$—y $^4P_{2\frac{1}{2}}$	4	0.26	0.13	0.93	1.32	1.58
1c	5334.27	18741.51	a $^2P_{1\frac{1}{2}}$—z $^4S_{1\frac{1}{2}}$						
3c	5326.341	18769.41	a $^2D_{1\frac{1}{2}}$—z $^4S_{1\frac{1}{2}}$						
2	5323.354	18779.94				0A	1.04A		
2	5321.917	18785.01	z $^6D_{3\frac{1}{2}}$—e $^6F_{4\frac{1}{2}}$						
2	5321.659	18785.92	b $^4D_{3\frac{1}{2}}$—y $^2P_{1\frac{1}{2}}$						
4	5321.323	18787.11	a $^2G_{4\frac{1}{2}}$—276b$_{3\frac{1}{2}}$†				0.78A		
3	5320.205	18791.05	a $^6D_{3\frac{1}{2}}$—z $^6F_{2\frac{1}{2}}$						
15, V	5319.485	18793.60	a $^4D_{1\frac{1}{2}}$—y $^4P_{2\frac{1}{2}}$						
80, III	5318.597	18796.74	a $^4F_{2\frac{1}{2}}$—z $^4D_{1\frac{1}{2}}$		0.230	0.117	0.680	1.025	1.255
5c	5317.804	18799.54	b $^2H_{5\frac{1}{2}}$—z $^2H_{4\frac{1}{2}}$						
4	5317.001	18802.38	a $^4H_{4\frac{1}{2}}$—z $^4H_{3\frac{1}{2}}$						
10	5315.543	18807.54	a $^4P_{1\frac{1}{2}}$—z $^2D_{2\frac{1}{2}}$	6			1.46?	(1.60)	1.32
3c	5314.283	18811.99	a $^4D_{3\frac{1}{2}}$—y $^2G_{4\frac{1}{2}}$						
3	5306.606	18839.21	a $^2D_{1\frac{1}{2}}$—y $^2P_{1\frac{1}{2}}$						
4c	5306.380	18840.01	a $^4H_{5\frac{1}{2}}$—y $^4G_{5\frac{1}{2}}$						
3	5303.27	18851.06	a $^4F_{1\frac{1}{2}}$—z $^6D_{2\frac{1}{2}}$						
2	5301.434	18857.59	b $^2H_{5\frac{1}{2}}$—e $^2G_{4\frac{1}{2}}$†				0.80A		
4	5298.95	18866.43	a $^4D_{2\frac{1}{2}}$—z $^6F_{1\frac{1}{2}}$						
4	5298.108	18869.43	a $^4H_{5\frac{1}{2}}$—y $^4G_{5\frac{1}{2}}$						
8c	5296.34	18875.72	b $^4P_{1\frac{1}{2}}$—w $^2D_{1\frac{1}{2}}$	6		0A	1.27	1.48?	(1.06)
2	5294.47	18882.40	a $^6D_{1\frac{1}{2}}$—z $^6F_{1\frac{1}{2}}$						
8c	5293.292	18886.59	b $^4D_{2\frac{1}{2}}$—e $^4D_{1\frac{1}{2}}$	6		0	1.41	1.43	(1.39)
2	5287.08	18908.78	a $^4D_{1\frac{1}{2}}$—276b$_{1\frac{1}{2}}$						
20c	5285.240	18915.37				w	1.08		
1	5281.62	18928.33	a $^2F_{2\frac{1}{2}}$—w $^4F_{1\frac{1}{2}}$						
8c	5279.418	18936.23	a $^4D_{3\frac{1}{2}}$—y $^2G_{3\frac{1}{2}}$						
5	5278.542	18939.37	a $^4P_{1\frac{1}{2}}$—z $^6P_{1\frac{1}{2}}$						
3	5277.42	18943.40	a $^4H_{5\frac{1}{2}}$—z $^4H_{4\frac{1}{2}}$						
30c, V	5276.196	18947.79	a $^6D_{3\frac{1}{2}}$—y $^4P_{2\frac{1}{2}}$	4	0.18	0.09	1.01	(1.42)	1.60
5	5272.48	18961.14	a $^4D_{1\frac{1}{2}}$—z $^4D_{1\frac{1}{2}}$						
60c, IV	5271.526	18964.58	a $^4F_{1\frac{1}{2}}$—z $^4D_{2\frac{1}{2}}$	5	0.42	0.21	0.61	0.40	—0.02
6	5269.910	18970.39	a $^2G_{3\frac{1}{2}}$—z $^2F_{2\frac{1}{2}}$	4	0.25		0.20	0.88	1.16
2c	5260.849	19003.07	a $^2D_{1\frac{1}{2}}$—z $^2P_{1\frac{1}{2}}$	4			1.05	(0.96)	0.78
3c	5260.13	19005.66					1.00w		
1c	5255.52	19022.23	b $^4F_{1\frac{1}{2}}$—z $^4G_{2\frac{1}{2}}$						
15, V	5253.926	19028.11	a $^2G_{3\frac{1}{2}}$—y $^2G_{3\frac{1}{2}}$	6		0	0.90	(0.88)	0.92
10	5253.028	19031.36	a $^4H_{5\frac{1}{2}}$—z $^4F_{4\frac{1}{2}}$	4us		w	0.98us	(1.12)	1.18
10c	5251.81	19035.77	a $^4D_{2\frac{1}{2}}$—z $^6F_{2\frac{1}{2}}$ a $^4D_{3\frac{1}{2}}$—z $^4D_{2\frac{1}{2}}$	4		0	1.30	(1.36)	1.44
15c, V	5251.62	19036.46	a $^6D_{3\frac{1}{2}}$—z $^6F_{3\frac{1}{2}}$						
10c	5247.38	19051.84	a $^4D_{3\frac{1}{2}}$—z $^4D_{3\frac{1}{2}}$	4		0	1.34w	1.41	(1.47)
4c	5241.50	19073.21	a $^4H_{5\frac{1}{2}}$—y $^4G_{5\frac{1}{2}}$						
5c	5240.39	19077.25	a $^4D_{1\frac{1}{2}}$—y $^4P_{1\frac{1}{2}}$						
16c	5237.43	19088.04	a $^4D_{2\frac{1}{2}}$—y $^4P_{2\frac{1}{2}}$	6		0	1.26	0.09	(2.47)
4	5236.837	19090.20	a $^2F_{3\frac{1}{2}}$—e $^4F_{4\frac{1}{2}}$						
3c	5235.096	19096.54	a $^2F_{3\frac{1}{2}}$—w $^4G_{4\frac{1}{2}}$						
1	5234.44	19098.94	a $^4P_{1\frac{1}{2}}$—y $^6F_{2\frac{1}{2}}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm⁻¹	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
25, V	5232.813	19104.88	a $^3G_{4\frac{1}{2}}$—y $^3G_{5\frac{1}{2}}$	6		w	1.11	(1.10)	1.12
2	5229.94	19115.37	b $^6F_{3\frac{1}{2}}$—r $^4F_{3\frac{1}{2}}$						
3	5229.37	19117.46	a $^3H_{4\frac{1}{2}}$—z $^4F_{3\frac{1}{2}}$						
12, V	5225.156	19132.87	a $^4H_{4\frac{1}{2}}$—y $^4G_{5\frac{1}{2}}$	4		w	1.14w	1.22	(1.23)
15c, V	5219.09	19155.11	a $^4D_{3\frac{1}{2}}$—y $^4F_{4\frac{1}{2}}$	4	0.34	0.17	0.58w	1.41	1.75
3c	5218.46	19157.42	b $^4F_{3\frac{1}{2}}$—u $^4F_{3\frac{1}{2}}$						
4c	5211.239	19183.97	z $^6F_{4\frac{1}{2}}$—e $^6F_{4\frac{1}{2}}$	5		0	1.66	(1.40)	1.46
2	5210.26	19187.57	b $^4F_{4\frac{1}{2}}$—w $^4F_{3\frac{1}{2}}$ b $^4D_{3\frac{1}{2}}$—v $^4G_{4\frac{1}{2}}$						
8	5205.132	19206.48	a $^3G_{4\frac{1}{2}}$—z $^3F_{3\frac{1}{2}}$	4		0?	1.03h	(1.10)	1.14
3c	5204.03	19210.54	z $^6F_{3\frac{1}{2}}$—e $^6F_{3\frac{1}{2}}$						
10, V	5203.224	19213.52	a $^4D_{1\frac{1}{2}}$—z $^3P_{1\frac{1}{2}}$ a $^3D_{1\frac{1}{2}}$—y $^3P_{1\frac{1}{2}}$	6	0.25	0.39	1.33	1.20	1.43
3	5201.938	19218.27	a $^3F_{3\frac{1}{2}}$—z $^3D_{3\frac{1}{2}}$						
3	5201.089	19221.41	a $^4D_{3\frac{1}{2}}$—z $^4F_{3\frac{1}{2}}$						
2c	5197.37	19235.16	a $^4D_{2\frac{1}{2}}$—y $^6P_{3\frac{1}{2}}$ a $^4H_{4\frac{1}{2}}$—z $^4F_{3\frac{1}{2}}$	4		0	0.43	(1.36)	1.98
20, IV	5195.859	19240.83	a $^4F_{3\frac{1}{2}}$—z $^4D_{3\frac{1}{2}}$	6		1.29	0.84	0.41	1.27
5	5193.454	19249.66	a $^3F_{2\frac{1}{2}}$—y $^3F_{3\frac{1}{2}}$						
40c, V	5193.078	19251.06	a $^4F_{3\frac{1}{2}}$—z $^4D_{3\frac{1}{2}}$	6	0.37	0.94	1.19	1.01	1.38
20, IV	5189.198	19265.45	a $^6D_{3\frac{1}{2}}$—z $^6D_{3\frac{1}{2}}$	7b, 5		0	1.57	(1.55)	1.54
15, IV	5186.987	19273.66	a $^6D_{1\frac{1}{2}}$—z $^6F_{2\frac{1}{2}}$	4	0.50	0.25	0.60	1.85	1.35
1h	5183.81	19285.47	b $^4D_{2\frac{1}{2}}$—y $^2D_{2\frac{1}{2}}$						
50, IV	5180.306	19298.52	a $^6D_{3\frac{1}{2}}$—z $^6D_{4\frac{1}{2}}$	7b, 5		0	1.61	(1.58)	1.56
3c	5178.209	19306.33	b $^6F_{3\frac{1}{2}}$—u $^6F_{3\frac{1}{2}}$			0	1.15		
2	5174.569	19319.91							
3	5174.198	19321.30	b $^4F_{2\frac{1}{2}}$—w $^4F_{2\frac{1}{2}}$						
1	5167.37	19346.83	b $^4D_{3\frac{1}{2}}$—y $^2S_{2\frac{1}{2}}$						
1	5166.96	19348.37	a $^4G_{3\frac{1}{2}}$—z $^4G_{3\frac{1}{2}}$						
40c, IV?	5164.368	19358.08	a $^4F_{3\frac{1}{2}}$—z $^4D_{2\frac{1}{2}}$	6	0.20	--	1.33	1.23	1.43
1	5161.63	19368.34	b $^4D_{1\frac{1}{2}}$—y $^2S_{2\frac{1}{2}}$						
30, IV?	5160.335	19373.20	a $^6D_{3\frac{1}{2}}$—z $^6D_{3\frac{1}{2}}$	4		0	-1.59	(1.65)	1.73
2	5158.030	19381.86	a $^6D_{4\frac{1}{2}}$—z $^6F_{3\frac{1}{2}}$?			--	1.80		
3	5157.486	19383.91	a $^3F_{3\frac{1}{2}}$—y $^3F_{3\frac{1}{2}}$						
2	5157.14	19385.21	a $^3D_{3\frac{1}{2}}$—y $^3D_{3\frac{1}{2}}$						
2	5153.63	19398.41	a $^3P_{1\frac{1}{2}}$—y $^3F_{2\frac{1}{2}}$						
6	5153.028	19400.68	b $^4D_{2\frac{1}{2}}$—x $^4F_{2\frac{1}{2}}$						
12c	5152.623	19402.20	a $^4D_{2\frac{1}{2}}$—y $^4F_{3\frac{1}{2}}$	6	0.24	0.60	?	(1.36)	1.60
7c	5150.636	19409.69	a $^4H_{4\frac{1}{2}}$—y $^4G_{5\frac{1}{2}}$						
12c	5147.537	19421.37	b $^4D_{3\frac{1}{2}}$—x $^4F_{3\frac{1}{2}}$	4		w	1.13	1.43	(1.55)
1c	5146.03	19427.06	b $^4F_{4\frac{1}{2}}$—x $^4G_{5\frac{1}{2}}$	5		w	1.30	(1.22)	1.24
1	5145.65	19428.49	b $^4D_{1\frac{1}{2}}$—x $^4F_{2\frac{1}{2}}$						
3	5140.68	19447.28	b $^2H_{4\frac{1}{2}}$—x $^2H_{5\frac{1}{2}}$						
8	5140.578	19447.66	b $^4F_{3\frac{1}{2}}$—u $^4F_{3\frac{1}{2}}$	6	0.19	0.47	0.94	0.85	1.04
3c	5137.398	19459.70	b $^4F_{4\frac{1}{2}}$—v $^4F_{3\frac{1}{2}}$						
2c	5135.47	19467.01	a $^4G_{3\frac{1}{2}}$—x $^4G_{3\frac{1}{2}}$						
40, IV?	5134.732	19469.73	a $^6D_{1\frac{1}{2}}$—z $^6D_{2\frac{1}{2}}$ b $^4F_{3\frac{1}{2}}$—u $^4F_{3\frac{1}{2}}$	4	1.16	0.58	1.27	1.85	3.01
7	5133.338	19475.09	a $^4P_{1\frac{1}{2}}$—z $^2D_{2\frac{1}{2}}$	4		--	0.70	(1.72)	1.81
1	5129.74	19488.78	a $^3F_{3\frac{1}{2}}$—w $^3D_{3\frac{1}{2}}$						
2	5128.278	19494.31	a $^3F_{2\frac{1}{2}}$—y $^3F_{3\frac{1}{2}}$						
9	5127.662	19496.65	a $^3P_{2\frac{1}{2}}$—y $^3D_{3\frac{1}{2}}$	5		--	0.89	(0.64)	0.81
4c	5124.694	19507.94	a $^4D_{3\frac{1}{2}}$—z $^3P_{2\frac{1}{2}}$						
12	5121.801	19518.96	b $^4F_{3\frac{1}{2}}$—w $^4G_{4\frac{1}{2}}$	6		0.18	1.08±	1.11	1.06
20, V?	5120.298	19524.69	a $^4D_{2\frac{1}{2}}$—z $^4F_{3\frac{1}{2}}$	4	0.23	--	0.92	1.63	1.49
3	5118.065	19533.21	a $^4G_{4\frac{1}{2}}$—w $^4F_{4\frac{1}{2}}$						
5	5116.741	19538.26	a $^2D_{2\frac{1}{2}}$—y $^2D_{2\frac{1}{2}}$						
6c	5110.910	19560.55	a $^4G_{5\frac{1}{2}}$—z $^4G_{5\frac{1}{2}}$	7b, 6		0	1.26	(1.27)	1.25
4c	5102.38	19593.25	a $^4G_{4\frac{1}{2}}$—v $^4F_{3\frac{1}{2}}$	5		w	1.37h	1.27	(1.22)
30, IV	5100.162	19601.78	a $^6D_{3\frac{1}{2}}$—z $^6D_{3\frac{1}{2}}$	6	0.08	0.19	1.60	1.64	1.56
3	5098.87	19606.74	a $^3G_{3\frac{1}{2}}$—y $^3G_{3\frac{1}{2}}$						
5c	5097.77	19610.97	a $^6D_{1\frac{1}{2}}$—z $^6D_{1\frac{1}{2}}$						
2	5096.57	19615.59	a $^4G_{4\frac{1}{2}}$—v $^4F_{4\frac{1}{2}}$						
7c	5095.535	19619.57	b $^4F_{3\frac{1}{2}}$—u $^4F_{3\frac{1}{2}}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	7	8	10
80c, IV?	5095.298	19620.48	$a\ ^6D_{3\frac{1}{2}}-z\ ^6D^0_{3\frac{1}{2}}$	6		0.11	1.58	1.59	1.57
3	5095.14	19621.09	$a\ ^2F_{2\frac{1}{2}}-u\ ^4F^0_{2\frac{1}{2}}$						
9c	5094.41	19623.90	$a\ ^6D_{2\frac{1}{2}}-z\ ^6D^0_{2\frac{1}{2}}$						
9c	5088.82	19645.46	$b\ ^4F_{1\frac{1}{2}}-w\ ^2F^0_{1\frac{1}{2}}$	5	0.58	0.25	1.86	0.41	0.99
3h	5086.83	19653.14	$a\ ^2H_{5\frac{1}{2}}-z\ ^4I^0_{5\frac{1}{2}}$						
2	5085.00	19660.22	$a\ ^4G_{3\frac{1}{2}}-z\ ^4I^0_{3\frac{1}{2}}$						
2	5084.83	19660.80	$b\ ^4F_{1\frac{1}{2}}-y\ ^4D^0_{1\frac{1}{2}}$						
2	5082.31	19670.62	$a\ ^4G_{2\frac{1}{2}}-y\ ^4F^0_{2\frac{1}{2}}$						
3	5079.314	19682.23	$a\ ^2F_{2\frac{1}{2}}-w\ ^2D^0_{2\frac{1}{2}}$						
150, IV	5078.959	19683.60	$a\ ^6D_{4\frac{1}{2}}-z\ ^6D^0_{4\frac{1}{2}}$	7b		0	1.55	(1.55)	1.55
7c	5077.391	19689.68	$a\ ^4G_{2\frac{1}{2}}-y\ ^4F^0_{1\frac{1}{2}}$	4			0.64	(0.74)	0.81
5c	5075.97	19695.19	$a\ ^4F_{1\frac{1}{2}}-z\ ^4D^0_{0\frac{1}{2}}$						
3c	5072.56	19708.43	$a\ ^2G_{3\frac{1}{2}}-z\ ^2F^0_{3\frac{1}{2}}$						
4c	5071.66	19711.93	$a\ ^4D_{3\frac{1}{2}}-z\ ^4D^0_{2\frac{1}{2}}$ $a\ ^6S_{2\frac{1}{2}}-z\ ^6G^0_{3\frac{1}{2}}$						
20, IV?	5065.256	19736.85	$a\ ^6D_{3\frac{1}{2}}-z\ ^6F^0_{2\frac{1}{2}}$	4		w	0.95+	(1.58)	1.44
3c	5064.45	19739.99	$a\ ^4D_{1\frac{1}{2}}-y\ ^4P^0_{1\frac{1}{2}}$						
1c	5060.99	19753.49	$b\ ^4F_{2\frac{1}{2}}-v\ ^2F^0_{3\frac{1}{2}}$						
10	5059.333	19759.88	$b\ ^4F_{2\frac{1}{2}}-u\ ^4F^0_{2\frac{1}{2}}$	5		--	1.80—	(0.85)	1.12
40, IV?	5057.909	19765.17	$a\ ^6D_{2\frac{1}{2}}-z\ ^6D^0_{1\frac{1}{2}}$	4		0.82	0.90	3.34	1.71
2c	5055.62	19774.47	$a\ ^4D_{3\frac{1}{2}}-z\ ^4H^0_{4\frac{1}{2}}$						
8	5054.671	19778.18	$b\ ^4F_{4\frac{1}{2}}-w\ ^4F^0_{3\frac{1}{2}}$ $b\ ^2H_{5\frac{1}{2}}-y\ ^4H^0_{4\frac{1}{2}}$	6		0.15	1.23±	1.21	1.25
2	5049.91	19796.83	$a\ ^4G_{3\frac{1}{2}}-w\ ^2F^0_{2\frac{1}{2}}$						
12c	5047.956	19804.49	$b\ ^4F_{2\frac{1}{2}}-z\ ^4F^0_{2\frac{1}{2}}$	7b		0	1.56	(1.56)	1.56
3	5046.756	19809.20	$b\ ^4F_{3\frac{1}{2}}-w\ ^4G^0_{3\frac{1}{2}}$						
5	5043.985	19820.08	$b\ ^4F_{3\frac{1}{2}}-w\ ^4G^0_{4\frac{1}{2}}$						
1h	5043.47	19822.11	$a\ ^2D_{2\frac{1}{2}}-z\ ^2S^0_{1\frac{1}{2}}$						
3c	5043.030	19823.84							
40, IV	5039.032	19839.56	$a\ ^6D_{1\frac{1}{2}}-z\ ^6D^0_{0\frac{1}{2}}$	4	0.298	0.149	1.123	1.868	1.870
1c	5037.89	19844.06	$a\ ^4D_{1\frac{1}{2}}-z\ ^4D^0_{0\frac{1}{2}}$						
6c	5035.99	19851.55	$b\ ^4F_{1\frac{1}{2}}-u\ ^4F^0_{0\frac{1}{2}}$						
5c	5031.864	19867.75	$a\ ^4G_{3\frac{1}{2}}-z\ ^4G^0_{3\frac{1}{2}}$						
7	5030.130	19874.67	$a\ ^2F_{3\frac{1}{2}}-w\ ^2D^0_{2\frac{1}{2}}$ $b\ ^4D_{3\frac{1}{2}}-v\ ^4G^0_{3\frac{1}{2}}$	4			1.05	1.14	(1.21)
3	5029.67	19876.49	$a\ ^4G_{3\frac{1}{2}}-w\ ^4F^0_{3\frac{1}{2}}$						
2	5028.65	19880.52	$a\ ^2G_{4\frac{1}{2}}-z\ ^2D^0_{3\frac{1}{2}}$						
20, V	5026.362	19889.57	$a\ ^4G_{2\frac{1}{2}}-u\ ^4F^0_{1\frac{1}{2}}$	4		--	0.72	(0.74)	0.77
8c	5019.512	19916.72	$b\ ^4F_{4\frac{1}{2}}-v\ ^2F^0_{3\frac{1}{2}}$	6		--	1.16	(1.12)	1.20
40, IV?	5017.743	19923.74	$a\ ^6D_{3\frac{1}{2}}-z\ ^6D^0_{2\frac{1}{2}}$	4		w	1.32	(1.65)	1.55
3c	5017.363	19925.25	$a\ ^4F_{3\frac{1}{2}}-z\ ^4D^0_{2\frac{1}{2}}$						
9c	5013.275	19941.49	$b\ ^4F_{3\frac{1}{2}}-w\ ^4F^0_{2\frac{1}{2}}$	5		--	1.40—	(1.12)	1.22
4	5011.750	19947.56	$a\ ^4D_{1\frac{1}{2}}-y\ ^4P^0_{1\frac{1}{2}}$ $b\ ^2G_{4\frac{1}{2}}-z\ ^2F^0_{3\frac{1}{2}}$						
6	5008.039	19962.34	$b\ ^4F_{3\frac{1}{2}}-v\ ^2F^0_{2\frac{1}{2}}$	6		0	0.84	(0.85)	0.83
12	5002.247	19985.46	$a\ ^2H_{4\frac{1}{2}}-w\ ^2F^0_{3\frac{1}{2}}$						
20c, V	5000.958	19990.61	$b\ ^4F_{4\frac{1}{2}}-u\ ^4F^0_{3\frac{1}{2}}$	6		0	1.24	1.22	(1.25)
4	5000.712	19991.59	$a\ ^6D_{3\frac{1}{2}}-z\ ^6D^0_{3\frac{1}{2}}$						
15, V	4997.880	20002.92	$a\ ^4G_{3\frac{1}{2}}-u\ ^4F^0_{2\frac{1}{2}}$	5		0	1.12	(1.08)	1.05
12	4994.303	20017.25					1.55—		
1	4993.83	20019.14	$a\ ^4G_{3\frac{1}{2}}-z\ ^4I^0_{4\frac{1}{2}}$						
3	4993.232	20021.54	$b\ ^4F_{3\frac{1}{2}}-w\ ^4D^0_{3\frac{1}{2}}$ $a\ ^4D_{3\frac{1}{2}}-z\ ^4H^0_{3\frac{1}{2}}$						
6c	4992.466	20024.61	$a\ ^4G_{4\frac{1}{2}}-z\ ^4I^0_{5\frac{1}{2}}$						
40, IV	4988.972	20038.64	$a\ ^6D_{3\frac{1}{2}}-z\ ^6D^0_{3\frac{1}{2}}$	4		0	1.45	(1.58)	1.53
1	4985.18	20053.88	$a\ ^2H_{4\frac{1}{2}}-z\ ^2I^0_{5\frac{1}{2}}$						
1	4976.75	20087.85	$b\ ^4F_{2\frac{1}{2}}-v\ ^4D^0_{1\frac{1}{2}}$						
10c	4975.135	20094.37	$a\ ^4G_{4\frac{1}{2}}-u\ ^4F^0_{3\frac{1}{2}}$	5		w	1.56—	1.21	(1.11)
15, V	4973.138	20102.44	$a\ ^2H_{5\frac{1}{2}}-v\ ^4F^0_{4\frac{1}{2}}$	4		--	1.20°	1.22?	(1.22)
10c	4971.917	20107.37	$a\ ^6D_{3\frac{1}{2}}-z\ ^4D^0_{2\frac{1}{2}}$						
30c, IV	4967.777	20124.13	$a\ ^4G_{3\frac{1}{2}}-u\ ^4F^0_{2\frac{1}{2}}$						
25c, V	4965.375	20133.86	$a\ ^4H_{5\frac{1}{2}}-z\ ^4G^0_{4\frac{1}{2}}$	5		0	0.81	(0.69)	0.64
7	4963.189	20142.73	$a\ ^6D_{4\frac{1}{2}}-z\ ^6D^0_{3\frac{1}{2}}$						
5h	4962.950	20143.70	$a\ ^4G_{4\frac{1}{2}}-w\ ^4G^0_{3\frac{1}{2}}$						
8c	4957.393	20166.28	$a\ ^4D_{2\frac{1}{2}}-z\ ^4D^0_{1\frac{1}{2}}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm⁻¹	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	7	8	10
3c	4956.60	20169.51	$a\ ^3H_{5/2}-z\ ^4I_{5/2}$				0.88w	(0.95)	0.81
7	4952.124	20183.66	$a\ ^3D_{1/2}-y\ ^3D_{1/2}$	6					
1	4951.54	20190.12	$a\ ^3G_{4/2}-z\ ^4H_{3/2}$						
12c	4945.432	20215.05	$a\ ^4G_{4/2}-z\ ^4G_{5/2}$ $b\ ^4D_{3/2}-z\ ^3D_{3/2}$	5		0	1.34	(1.23)	1.28
2h	4941.905	20229.48	$a\ ^5D_{1/2}-z\ ^4D_{1/2}$						
9	4941.513	20231.09	$a\ ^3H_{4/2}-w\ ^4F_{5/2}$						
1h	4937.45	20247.73	$a\ ^4G_{4/2}-s\ ^4F_{3/2}$						
2	4933.20	20265.18	$a\ ^4D_{3/2}-y\ ^4G_{3/2}$						
2	4932.140	20269.53	$b\ ^3G_{3/2}-s\ ^4G_{3/2}$						
4	4929.556	20280.16	$a\ ^3H_{4/2}-z\ ^4I_{3/2}$						
15, IV?	4928.969	20282.57	$b\ ^4F_{3/2}-w\ ^4G_{3/2}$	5		0	1.32	(1.22)	1.25
6c	4924.862	20299.49	$a\ ^3H_{5/2}-w\ ^4G_{3/2}$						
1	4921.07	20315.13	$a\ ^4G_{3/2}-u\ ^4F_{3/2}$						
3h	4920.75	20316.45	$a\ ^4D_{3/2}-y\ ^4G_{3/2}$						
15c	4916.392	20334.46							
7	4915.842	20336.74	$a\ ^3D_{1/2}-y\ ^3D_{3/2}$						
30, IV	4910.948	20357.00	$a\ ^3F_{3/2}-s\ ^4D_{3/2}$	?		w	1.10+		
7c	4908.716	20366.26	$b\ ^4F_{3/2}-s\ ^3F_{3/2}$						
3	4908.331	20367.85	$b\ ^3G_{3/2}-t\ ^4F_{3/2}$						
25, IV	4904.534	20383.62	$a\ ^6D_{3/2}-z\ ^4D_{1/2}$	4		1.03	0.24	(3.32)	1.27
1h	4903.02	20389.92	$a\ ^3P_{3/2}-s\ ^4F_{3/2}$ $b\ ^3H_{4/2}-x\ ^4H_{3/2}$						
20, III	4900.786	20399.21	$a\ ^3H_{4/2}-w\ ^4G_{3/2}$	4		w	0.51+	(0.93)	1.05
4	4898.491	20408.77	$a\ ^4G_{3/2}-w\ ^4D_{3/2}$						
2	4897.51	20412.86	$b\ ^3G_{3/2}-w\ ^3H_{3/2}$						
10c	4895.574	20420.93	$a\ ^4P_{3/2}-y\ ^5D_{3/2}$ $a\ ^3H_{3/2}-w\ ^4F_{3/2}$						
12c	4892.80	20433.76	$a\ ^4G_{3/2}-u\ ^4F_{3/2}$ $a\ ^3G_{4/2}-y\ ^4G_{3/2}$						
25, IV	4890.739	20441.12	$a\ ^4H_{3/2}-x\ ^4G_{3/2}$	4		0	0.96	(0.98)	0.99
3	4889.809	20445.00							
7c	4889.551	20446.08	$a\ ^6D_{3/2}-z\ ^4D_{3/2}$			w	1.20°		
5	4885.765	20461.93	$a\ ^6D_{4/2}-z\ ^4D_{3/2}$						
2	4881.68	20479.05	$a\ ^3D_{3/2}-y\ ^3F_{3/2}$						
8c	4880.714	20483.10	$a\ ^4G_{3/2}-w\ ^4G_{3/2}$						
1	4879.20	20489.46	$a\ ^3P_{1/2}-s\ ^4F_{3/2}$						
5	4878.496	20492.41	$b\ ^4P_{3/2}-x\ ^4P_{3/2}$						
5	4872.505	20517.61	$a\ ^4G_{3/2}-s\ ^3F_{3/2}$ $a\ ^3G_{4/2}-z\ ^4H_{3/2}$						
20, V	4868.99	20532.42	$z\ ^6G_{3/2}-e\ ^6F_{3/2}$ $a\ ^3G_{3/2}-y\ ^4G_{3/2}$?						
12c	4866.842	20541.49	$b\ ^4P_{1/2}-s\ ^3D_{3/2}$ $a\ ^4G_{3/2}-s\ ^3F_{3/2}$			w	1.00+°		
2	4860.994	20566.20	$a\ ^4G_{4/2}-w\ ^4F_{3/2}$						
1h	4857.31	20581.79	$a\ ^4P_{3/2}-y\ ^5D_{3/2}$						
1	4853.89	20596.30	$b\ ^4P_{1/2}-y\ ^3S_{3/2}$						
6	4852.273	20603.16							
7c	4851.881	20604.83	$a\ ^4G_{3/2}-z\ ^3D_{3/2}$ $b\ ^3G_{3/2}-u\ ^4G_{3/2}$						
2	4849.35	20615.58	$a\ ^3P_{1/2}-w\ ^3F_{3/2}$						
100c, V	4848.359	20619.79	$a\ ^4D_{3/2}-y\ ^4G_{3/2}$	4		w	0.77+	(1.42)	1.28
3h	4847.39	20623.91	$b\ ^4P_{3/2}-y\ ^3P_{1/2}$						
2	4845.46	20632.13	$a\ ^4P_{1/2}-y\ ^4F_{1/2}$						
20, V	4845.170	20633.36	$a\ ^3H_{4/2}-u\ ^4F_{3/2}$	4		w	0.45+	1.10	(1.25)
20c	4842.139	20646.28	$a\ ^4G_{4/2}-w\ ^4D_{3/2}$	4		w	0.94	1.25	(1.34)
1	4840.39	20653.74	$a\ ^3F_{3/2}-s\ ^4D_{3/2}$						
1	4840.28	20654.21	$a\ ^4D_{1/2}-y\ ^4G_{3/2}$						
20c, V	4837.98	20664.03	$a\ ^4D_{3/2}-x\ ^4F_{3/2}$						
15	4837.615	20665.59	$z\ ^6G_{3/2}-e\ ^6F_{3/2}$ $a\ ^4G_{3/2}-w\ ^4G_{3/2}$						
40, III?	4833.362	20683.77	$a\ ^6D_{1/2}-z\ ^4D_{1/2}$	4	0.46	0.23	0.72	1.86	1.40
3	4832.21	20688.70	$183_{3/2}-w\ ^3H_{3/2}$						
2	4830.69	20695.21	$a\ ^3P_{1/2}-w\ ^4F_{3/2}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm⁻¹	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
20, V	4829.302	20701.16	$z\ ^6G_{3\frac{1}{2}}-e\ ^6F_{3\frac{1}{2}}$			w	0.89+	1.29	(1.40)
1	4826.97	20711.16	$b\ ^2H_{4\frac{1}{2}}-f\ ^4F_{3\frac{1}{2}}$						
1	4826.50	20713.18	$b\ ^4D_{2\frac{1}{2}}-u\ ^4D_{3\frac{1}{2}}$						
6c	4824.954	20719.81	$a\ ^3F_{3\frac{1}{2}}-w\ ^3G_{3\frac{1}{2}}$						
3	4821.11	20736.33	$a\ ^4D_{2\frac{1}{2}}-x\ ^4F_{3\frac{1}{2}}$						
1	4820.07	20740.81	$b\ ^4D_{1\frac{1}{2}}-u\ ^4D_{2\frac{1}{2}}$						
80c, IV	4816.375	20756.72	$a\ ^4H_{4\frac{1}{2}}-x\ ^4G_{3\frac{1}{2}}$ $a\ ^4H_{4\frac{1}{2}}-x\ ^2G_{3\frac{1}{2}}$	4		0	1.10	(1.12)	1.12
2	4814.98	20762.73	$a\ ^4P_{1\frac{1}{2}}-y\ ^4F_{2\frac{1}{2}}$						
2	4812.12	20775.07	$b\ ^2H_{4\frac{1}{2}}-y\ ^2H_{5\frac{1}{2}}$						
12c	4811.287	20778.67	$a\ ^4G_{4\frac{1}{2}}-u\ ^4F_{4\frac{1}{2}}$	6		0	1.23	1.21	(1.25)
100c, V	4810.584	20781.70	$a\ ^4D_{3\frac{1}{2}}-x\ ^4F_{4\frac{1}{2}}$						
30, V	4809.357	20787.01	$a\ ^4G_{3\frac{1}{2}}-w\ ^4F_{3\frac{1}{2}}$						
4	4809.12	20788.03	$a\ ^2D_{2\frac{1}{2}}-y\ ^2F_{3\frac{1}{2}}$						
4c	4809.03	20788.42	$a\ ^2G_{4\frac{1}{2}}-y\ ^4G_{5\frac{1}{2}}$						
10	4807.052	20796.98	$a\ ^2H_{4\frac{1}{2}}-y\ ^2F_{3\frac{1}{2}}$						
3	4805.61	20803.22							
9	4802.442	20816.94	$a\ ^6D_{3\frac{1}{2}}-z\ ^6D_{3\frac{1}{2}}$†			2.56	1.44+		
2	4798.818	20832.66	$a\ ^2G_{3\frac{1}{2}}-x\ ^4F_{3\frac{1}{2}}$						
5c	4793.07	20857.64	$a\ ^4H_{4\frac{1}{2}}-z\ ^4H_{5\frac{1}{2}}$						
9	4790.902	20867.08	$a\ ^4P_{2\frac{1}{2}}-y\ ^6D_{3\frac{1}{2}}$ $a\ ^4G_{3\frac{1}{2}}-w\ ^4D_{2\frac{1}{2}}$ $b\ ^4D_{2\frac{1}{2}}-u\ ^4D_{3\frac{1}{2}}$						
6d	4790.58	20868.48	$a\ ^4F_{3\frac{1}{2}}-z\ ^4G_{4\frac{1}{2}}$						
3	4787.73	20880.91	$a\ ^4G_{3\frac{1}{2}}-v\ ^2F_{3\frac{1}{2}}$						
1	4787.56	20881.65	$a\ ^4P_{2\frac{1}{2}}-y\ ^6D_{2\frac{1}{2}}$						
7	4785.607	20889.78	$b\ ^4F_{3\frac{1}{2}}-v\ ^4D_{2\frac{1}{2}}$						
8c	4784.30	20895.88	$b\ ^2G_{3\frac{1}{2}}-r\ ^2F_{3\frac{1}{2}}$	5		0	0.91	0.89	(0.88)
4	4782.948	20901.78	$a\ ^2H_{4\frac{1}{2}}-w\ ^4D_{3\frac{1}{2}}$						
1	4782.44	20904.00	$b\ ^4D_{2\frac{1}{2}}-w\ ^6S_{2\frac{1}{2}}$ $a\ ^6S_{2\frac{1}{2}}-w\ ^4D_{1\frac{1}{2}}$						
5c	4780.98	20910.38	$b\ ^4D_{3\frac{1}{2}}-w\ ^6S_{2\frac{1}{2}}$						
1	4780.07	20914.37	$a\ ^3F_{3\frac{1}{2}}-w\ ^3G_{3\frac{1}{2}}$						
6c	4777.62	20925.09	$a\ ^2H_{4\frac{1}{2}}-w\ ^4G_{3\frac{1}{2}}$	†		w	1.46—		
2	4776.224	20931.21	$a\ ^4P_{2\frac{1}{2}}-z\ ^3G_{3\frac{1}{2}}$						
2	4776.07	20931.88	$a\ ^4P_{2\frac{1}{2}}-y\ ^4F_{3\frac{1}{2}}$ $b\ ^4D_{1\frac{1}{2}}-w\ ^6S_{2\frac{1}{2}}$						
20c	4773.24	20944.29	$a\ ^4D_{3\frac{1}{2}}-x\ ^4F_{3\frac{1}{2}}$						
5c	4772.79	20946.27	$b\ ^2G_{4\frac{1}{2}}-u\ ^2G_{3\frac{1}{2}}$						
1	4772.20	20948.86	$a\ ^2G_{3\frac{1}{2}}-y\ ^2D_{2\frac{1}{2}}$						
7	4771.852	20950.38	$a\ ^2G_{4\frac{1}{2}}-x\ ^4F_{3\frac{1}{2}}$						
5	4767.07	20971.40	$a\ ^4P_{2\frac{1}{2}}-y\ ^4D_{1\frac{1}{2}}$						
30c, V	4766.80	20972.59	$z\ ^6G_{3\frac{1}{2}}-e\ ^6F_{2\frac{1}{2}}$ $b\ ^2H_{4\frac{1}{2}}-w\ ^2H_{5\frac{1}{2}}$	4 5		0 0	0.68 1.12	1.13 0.99	(1.31) L (0.93)
6	4766.53	20973.78	$z\ ^6G_{3\frac{1}{2}}-e\ ^6F_{3\frac{1}{2}}$						
2c	4758.12	21010.85	$a\ ^4H_{3\frac{1}{2}}-w\ ^2F_{3\frac{1}{2}}$						
4	4756.538	21017.84	$a\ ^4P_{2\frac{1}{2}}-z\ ^6D_{3\frac{1}{2}}$						
10c	4755.318	21023.23	$b\ ^4F_{4\frac{1}{2}}-v\ ^4D_{3\frac{1}{2}}$						
5	4754.957	21024.82	$b\ ^4F_{3\frac{1}{2}}-v\ ^4D_{2\frac{1}{2}}$						
3d	4753.48	21031.36							
1	4752.86	21034.10	$a\ ^2H_{4\frac{1}{2}}-u\ ^4F_{3\frac{1}{2}}$						
3h	4752.10	21037.46	$b\ ^2H_{4\frac{1}{2}}-z\ ^4H_{5\frac{1}{2}}$						
20	4751.44	21040.39	$z\ ^6G_{3\frac{1}{2}}-e\ ^6F_{3\frac{1}{2}}$						
5	4750.74	21043.49	$a\ ^4H_{3\frac{1}{2}}-w\ ^2F_{2\frac{1}{2}}$						
200c, V	4749.706	21048.07	$a\ ^4H_{4\frac{1}{2}}-x\ ^4G_{4\frac{1}{2}}$	4		w	1.14w	1.21	(1.24)
3c	4748.84	21051.91	$b\ ^4D_{3\frac{1}{2}}-u\ ^4D_{4\frac{1}{2}}$						
3h	4748.04	21055.45							
9c	4746.967	21060.12	$a\ ^4F_{4\frac{1}{2}}-z\ ^4G_{5\frac{1}{2}}$						
10c	4745.020	21068.85	$a\ ^4P_{2\frac{1}{2}}-y\ ^2D_{2\frac{1}{2}}$ $a\ ^4G_{3\frac{1}{2}}-w\ ^2D_{2\frac{1}{2}}$						
30, V	4744.622	21070.63	$a\ ^4G_{4\frac{1}{2}}-w\ ^4G_{3\frac{1}{2}}$	5		0	1.41	(1.23)	1.26
15, V	4743.839	21074.10	$a\ ^4D_{1\frac{1}{2}}-z\ ^4F_{2\frac{1}{2}}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm⁻¹	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
4c	4742.43	21080.36							
3	4742.072	21081.95	$a\ ^4H_{3\frac{1}{2}}-z\ ^4G_{3\frac{1}{2}}$						
15c	4740.61	21088.45	$a\ ^4F_{1\frac{1}{2}}-y\ ^4D_{1\frac{1}{2}}$	4		0	1.50	(1.72)	1.63
2	4740.426	21089.27	$b\ ^4F_{3\frac{1}{2}}-w\ ^2G_{3\frac{1}{2}}$						
20c	4736.49	21106.80	$b\ ^2H_{5\frac{1}{2}}-y\ ^2H_{5\frac{1}{2}}$	3		w	1.55—	1.01	(1.00)
10	4735.339	21111.93	$a\ ^4H_{4\frac{1}{2}}-z\ ^4H_{5\frac{1}{2}}$						
60c, V	4733.885	21118.41	$a\ ^4D_{3\frac{1}{2}}-z\ ^4F_{4\frac{1}{2}}$	4	0.17	0.09	0.77+	1.37	1.20
30c, V	4733.483	21120.20	$a\ ^4D_{2\frac{1}{2}}-z\ ^4D_{1\frac{1}{2}}$						
20	4730.312	21134.36	$a\ ^4H_{4\frac{1}{2}}-z\ ^4H_{4\frac{1}{2}}$	6		0.79—	...	(1.12)	0.98
10c	4727.320	21147.74	$a\ ^4H_{6\frac{1}{2}}-z\ ^4H_{5\frac{1}{2}}$						
4d	4726.77	21150.20							
2	4724.48	21160.45	$a\ ^2G_{3\frac{1}{2}}-x\ ^4F_{3\frac{1}{2}}$						
15c	4723.795	21163.52	$z\ ^4G_{5\frac{1}{2}}-e\ ^6F_{4\frac{1}{2}}$						
3	4723.146	21166.43				0	0.96		
2	4720.10	21180.08	$b\ ^4F_{2\frac{1}{2}}-x\ ^4D_{1\frac{1}{2}}$						
8	4718.024	21189.40							
20	4715.819	21199.31	$z\ ^4G_{5\frac{1}{2}}-e\ ^6F_{5\frac{1}{2}}$	4		0.34	0.34A	0.00	−0.08
80, V	4713.495	21209.76	$a\ ^4F_{4\frac{1}{2}}-z\ ^4F_{5\frac{1}{2}}$	5		w	1.635	(1.330)	1.243
9c	4713.038	21211.82	$a\ ^4D_{3\frac{1}{2}}-y\ ^2D_{2\frac{1}{2}}$						
6d	4711.872	21217.07	$\begin{cases} a\ ^6H_{3\frac{1}{2}}-u\ ^4F_{3\frac{1}{2}} \\ a\ ^2H_{4\frac{1}{2}}-w\ ^2G_{3\frac{1}{2}} \end{cases}$						
150, IV?	4708.284	21233.24	$a\ ^4H_{3\frac{1}{2}}-z\ ^4H_{4\frac{1}{2}}$	5	0.146	0.216	1.273	(0.690)	0.836
5d	4707.103	21238.57	$b\ ^4F_{3\frac{1}{2}}-x\ ^4F_{4\frac{1}{2}}$						
100c, V	4706.132	21242.95				0	1.082		
4	4705.09	21247.65	$a\ ^2D_{2\frac{1}{2}}-x\ ^4G_{3\frac{1}{2}}$						
4	4703.92	21252.94	$a\ ^4G_{3\frac{1}{2}}-w\ ^2D_{2\frac{1}{2}}$						
5	4702.02	21261.53	$b\ ^2G_{3\frac{1}{2}}-t\ ^2D_{2\frac{1}{2}}$						
4	4697.752	21280.84	$b\ ^4F_{3\frac{1}{2}}-u\ ^4D_{2\frac{1}{2}}$						
30, V	4697.468	21282.13	$a\ ^4D_{1\frac{1}{2}}-z\ ^4F_{2\frac{1}{2}}$	4	0.19	0.09	0.72+	1.20	1.01
2	4695.93	21289.10	$a\ ^4H_{4\frac{1}{2}}-w\ ^4F_{4\frac{1}{2}}$						
20c, V	4695.46	21291.23	$a\ ^4H_{3\frac{1}{2}}-x\ ^2G_{3\frac{1}{2}}$	5	0.40			(0.690)	1.09
15c, V	4694.50	21295.58	$z\ ^6G_{5\frac{1}{2}}-e\ ^6F_{5\frac{1}{2}}$						
3	4692.253	21305.77	$183_{5\frac{1}{2}}-t\ ^2G_{4\frac{1}{2}}$			0	0.96		
10	4689.162	21319.82							
5c	4688.83	21321.33							
4	4688.49	21322.88							
3	4687.790	21326.06	$a\ ^2H_{4\frac{1}{2}}-w\ ^4G_{3\frac{1}{2}}$						
1A	4687.19	21328.79	$a\ ^2G_{4\frac{1}{2}}-y\ ^4G_{3\frac{1}{2}}$						
9	4685.925	21334.55	$\begin{cases} z\ ^6G_{5\frac{1}{2}}-e\ ^6F_{3\frac{1}{2}} \\ a\ ^2G_{3\frac{1}{2}}-x\ ^4F_{3\frac{1}{2}} \end{cases}$						
9	4685.518	21336.41	$a\ ^2F_{3\frac{1}{2}}-s\ ^2F_{3\frac{1}{2}}$						
100, V?	4685.133	21338.16	$a\ ^4H_{4\frac{1}{2}}-z\ ^4H_{5\frac{1}{2}}$	7½, 5		0	0.986	(0.984)	0.984
1	4683.68	21344.78	$b\ ^2G_{4\frac{1}{2}}-u\ ^2G_{3\frac{1}{2}}$						
7	4682.984	21347.95	$a\ ^2F_{3\frac{1}{2}}-v\ ^2D_{2\frac{1}{2}}$						
10c	4682.664	21349.41	$z\ ^6G_{5\frac{1}{2}}-e\ ^6F_{3\frac{1}{2}}$						
2	4681.997	21352.45							
3	4681.66	21353.99							
1	4681.53	21354.58							
4c	4680.890	21357.50	$a\ ^4H_{3\frac{1}{2}}-s\ ^4F_{3\frac{1}{2}}$						
22d, V	4678.48	21368.50	$a\ ^4D_{2\frac{1}{2}}-z\ ^4F_{3\frac{1}{2}}$	5	0.33	0.19	0.62	0.05	0.43
150, V?	4675.371	21382.71	$a\ ^6F_{3\frac{1}{2}}-z\ ^6G_{3\frac{1}{2}}$	4		w	0.91	(1.24)	1.17
12c	4673.589	21390.86	$b\ ^2G_{4\frac{1}{2}}-t\ ^2G_{3\frac{1}{2}}$						
200c, V?	4672.097	21397.69	$a\ ^4F_{4\frac{1}{2}}-z\ ^4G_{5\frac{1}{2}}$	4		w	0.96	(1.33)	1.26
3c	4670.87	21403.32	$\begin{cases} a\ ^4G_{3\frac{1}{2}}-z\ ^2H_{3\frac{1}{2}} \\ b\ ^2H_{4\frac{1}{2}}-r\ ^2F_{3\frac{1}{2}} \end{cases}$						
10	4669.868	21407.91	$a\ ^4H_{4\frac{1}{2}}-u\ ^4F_{3\frac{1}{2}}$						
2c	4669.32	21410.42	$a\ ^4H_{3\frac{1}{2}}-w\ ^4F_{3\frac{1}{2}}$						
3c	4668.966	21412.04							
6	4668.232	21415.41	$a\ ^4F_{1\frac{1}{2}}-z\ ^4D_{1\frac{1}{2}}$						
80, V	4667.224	21420.03	$\begin{cases} a\ ^4F_{2\frac{1}{2}}-z\ ^4F_{2\frac{1}{2}} \\ a\ ^4F_{3\frac{1}{2}}-z\ ^4F_{3\frac{1}{2}} \end{cases}$	5	0.179	0.093	1.673	(1.235)	1.056
6c	4666.630	21422.76	$b\ ^2H_{4\frac{1}{2}}-y\ ^2H_{5\frac{1}{2}}$						
100, IV?	4666.251	21424.50	$a\ ^4H_{3\frac{1}{2}}-z\ ^4H_{3\frac{1}{2}}$	4		w	0.92	(1.12)	1.09
10	4665.333	21428.72	$b\ ^4F_{1\frac{1}{2}}-s\ ^4D_{1\frac{1}{2}}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	7	8	10
5	4664.306	21433.16	$b\ {}^4F_{1\frac{1}{2}}-z\ {}^2H_{1\frac{1}{2}}$						
4	4663.97	21434.98	$b\ {}^4D_{2\frac{1}{2}}-y\ {}^4H_{3\frac{1}{2}}$						
100, IV?	4663.831	21435.62	$a\ {}^4F_{1\frac{1}{2}}-z\ {}^4G_{1\frac{1}{2}}$	4			0.862	(1.029)	0.981
4c	4662.89	21439.94	$b\ {}^4P_{1\frac{1}{2}}-u\ {}^4D_{1\frac{1}{2}}$						
5h	4660.98	21448.73	$a\ {}^2F_{2\frac{1}{2}}-p\ {}^4G_{2\frac{1}{2}}$						
3h	4660.70	21450.02	$a\ {}^2D_{2\frac{1}{2}}-z\ {}^2F_{3\frac{1}{2}}$						
12	4658.186	21461.50	$a\ {}^4P_{2\frac{1}{2}}-z\ {}^4D_{2\frac{1}{2}}$						
1	4655.953	21471.89	$b\ {}^4P_{2\frac{1}{2}}-w\ {}^4S_{1\frac{1}{2}}$						
1	4654.89	21476.79	$b\ {}^4F_{2\frac{1}{2}}-p\ {}^4D_{1\frac{1}{2}}$						
3	4652.08	21489.77							
2	4649.622	21501.12	$a\ {}^2H_{3\frac{1}{2}}-z\ {}^2I_{3\frac{1}{2}}$						
40, V	4649.265	21502.82							
100, IV?	4648.949	21504.24	$a\ {}^4F_{1\frac{1}{2}}-z\ {}^4G_{1\frac{1}{2}}$	5	0.175	0.087	0.841	0.403	0.573
20c	4646.952	21513.48	$183_{3\frac{1}{2}}-p\ {}^2H_{3\frac{1}{2}}$			w	0.79+		
4c	4645.84	21518.63							
5c	4643.86	21527.80	$a\ {}^4D_{3\frac{1}{2}}-y\ {}^2F_{3\frac{1}{2}}$?						
10c	4643.682	21528.63	$a\ {}^4H_{3\frac{1}{2}}-z\ {}^4G_{3\frac{1}{2}}$						
10	4643.315	21530.33	$a\ {}^4F_{2\frac{1}{2}}-z\ {}^4F_{2\frac{1}{2}}$						
3	4642.46	21534.29							
5	4640.248	21544.56	$b\ {}^2H_{3\frac{1}{2}}-w\ {}^2H_{3\frac{1}{2}}$						
4	4638.17	21554.21	$a\ {}^4P_{2\frac{1}{2}}-z\ {}^4D_{3\frac{1}{2}}$	6		d?	2.54±	(2.65)	2.43
10	4638.105	21554.51	$a\ {}^4H_{3\frac{1}{2}}-w\ {}^4G_{3\frac{1}{2}}$ $a\ {}^6S_{2\frac{1}{2}}-p\ {}^5F_{3\frac{1}{2}}$						
5c	4633.80	21574.54							
1	4632.25	21581.76	$a\ {}^2P_{2\frac{1}{2}}-p\ {}^4F_{1\frac{1}{2}}$						
3	4631.976	21583.03							
3h	4630.30	21590.85							
100, IV?	4630.115	21591.71	$a\ {}^4H_{3\frac{1}{2}}-z\ {}^4I_{3\frac{1}{2}}$	4		w	0.994	1.22	1.19
7d	4627.477	21604.02							
1	4625.335	21614.02	$b\ {}^4F_{1\frac{1}{2}}-y\ {}^2P_{2\frac{1}{2}}$						
4c	4624.576	21617.57	$a\ {}^2D_{1\frac{1}{2}}-x\ {}^4G_{2\frac{1}{2}}$						
6	4622.336	21628.04				w	1.12±		
2	4620.02	21638.89	$a\ {}^4P_{1\frac{1}{2}}-y\ {}^4D_{1\frac{1}{2}}$						
3	4619.42	21641.70	$a\ {}^2F_{2\frac{1}{2}}-p\ {}^4G_{3\frac{1}{2}}$						
80, V	4616.162	21656.97	$a\ {}^4F_{1\frac{1}{2}}-z\ {}^4F_{1\frac{1}{2}}$	5	0.007	0.301	1.941	1.030	0.416
8c	4614.740	21663.64	$a\ {}^2F_{3\frac{1}{2}}-u\ {}^2F_{3\frac{1}{2}}$						
4	4612.465	21674.33							
8	4612.108	21676.01	$a\ {}^4H_{3\frac{1}{2}}-w\ {}^4F_{3\frac{1}{2}}$						
2	4612.02	21676.42	$183_{3\frac{1}{2}}-s\ {}^4F_{3\frac{1}{2}}$						
7c	4610.698	21682.64	$a\ {}^4H_{3\frac{1}{2}}-p\ {}^4F_{3\frac{1}{2}}$						
4	4610.106	21685.43	$a\ {}^4P_{1\frac{1}{2}}-z\ {}^4D_{1\frac{1}{2}}$						
9c	4608.567	21692.66	$b\ {}^4F_{4\frac{1}{2}}-z\ {}^2H_{3\frac{1}{2}}$						
1	4607.28	21698.72	$a\ {}^4G_{3\frac{1}{2}}-p\ {}^4D_{2\frac{1}{2}}$						
200, III	4606.760	21701.17	$a\ {}^4F_{4\frac{1}{2}}-z\ {}^4F_{3\frac{1}{2}}$	7b, 6		0	1.334	(1.332)	1.336
4	4605.649	21706.41							
5c	4603.797	21715.14	$a\ {}^4P_{2\frac{1}{2}}-z\ {}^4D_{1\frac{1}{2}}$						
7	4602.864	21719.54	$a\ {}^4P_{2\frac{1}{2}}-y\ {}^4D_{2\frac{1}{2}}$						
2	4602.48	21721.35	$b\ {}^4F_{2\frac{1}{2}}-x\ {}^4F_{1\frac{1}{2}}$						
30, V	4600.22	21732.02	$a\ {}^2H_{3\frac{1}{2}}-w\ {}^2G_{3\frac{1}{2}}$	7b		0	1.10−	(1.10)	1.10
10c	4599.475	21735.54	$a\ {}^2D_{1\frac{1}{2}}-y\ {}^2S_{1\frac{1}{2}}$						
4	4592.42	21768.93	$a\ {}^2P_{1\frac{1}{2}}-w\ {}^2D_{2\frac{1}{2}}$						
6c	4584.849	21804.88	$b\ {}^4P_{1\frac{1}{2}}-u\ {}^4D_{1\frac{1}{2}}$						
7c	4583.49	21811.34	$a\ {}^4G_{4\frac{1}{2}}-p\ {}^4D_{3\frac{1}{2}}$						
4	4583.132	21813.05							
20, V	4582.283	21817.09	$a\ {}^4P_{2\frac{1}{2}}-y\ {}^4P_{1\frac{1}{2}}$	4		--	1.521	(1.596)	1.646
100, V	4581.623	21820.23	$a\ {}^2H_{3\frac{1}{2}}-z\ {}^2I_{3\frac{1}{2}}$	4		w	1.03	(1.10)	1.08
12	4575.372	21850.04	$a\ {}^2D_{2\frac{1}{2}}-w\ {}^2F_{3\frac{1}{2}}$						
25c, V	4574.848	21852.54	$a\ {}^6D_{3\frac{1}{2}}-z\ {}^6F_{3\frac{1}{2}}$	4		0.298	--	(1.863)	2.489
2	4574.572	21853.86	$a\ {}^4G_{3\frac{1}{2}}-p\ {}^4D_{2\frac{1}{2}}$						
7	4574.338	21854.98	$a\ {}^4H_{4\frac{1}{2}}-p\ {}^4F_{3\frac{1}{2}}$						
200c, III	4573.077	21861.01	$a\ {}^4F_{3\frac{1}{2}}-z\ {}^4F_{3\frac{1}{2}}$	7b, 6		0	1.23	(1.23)	1.23

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ_{air} A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
6	4570.960	21871.13	$b\ {}^4F_{3\frac{1}{2}}-y\ {}^4G_{3\frac{1}{2}}$	6	0.09	0.32	...	(1.12)	1.03
4	4569.49	21878.17							
6c	4569.15	21879.80	$a\ {}^4H_{4\frac{1}{2}}-w\ {}^4F_{3\frac{1}{2}}$						
2h	4567.84	21888.47	$a\ {}^4H_{3\frac{1}{2}}-u\ {}^4F_{2\frac{1}{2}}$						
4	4567.11	21989.57	$\begin{cases} a\ {}^3G_{3\frac{1}{2}}-y\ {}^3F_{3\frac{1}{2}} \\ a\ {}^4P_{2\frac{1}{2}}-y\ {}^3G_{3\frac{1}{2}} \end{cases}$						
60, V	4564.530	21901.94	$a\ {}^3H_{4\frac{1}{2}}-z\ {}^3H_{3\frac{1}{2}}$	7b, 5		0	0.96	0.93	(0.94)
6c	4564.205	21903.50	$a\ {}^4H_{3\frac{1}{2}}-w\ {}^4G_{3\frac{1}{2}}$						
2	4562.33	21912.50	$a\ {}^3H_{3\frac{1}{2}}-z\ {}^3H_{3\frac{1}{2}}$						
4c	4561.47	21916.63							
5	4559.429	21926.44							
15	4556.854	21938.83	$\begin{cases} a\ {}^4P_{2\frac{1}{2}}-y\ {}^4D_{3\frac{1}{2}} \\ a\ {}^4F_{3\frac{1}{2}}-z\ {}^3D_{3\frac{1}{2}} \end{cases}$	4		0	0.67? q	(2.65)	1.27
3	4555.556	21945.08							
30, V	4553.539	21953.36	$a\ {}^4P_{2\frac{1}{2}}-z\ {}^3P_{1\frac{1}{2}}$	5		w	1.79	(1.60)	1.47
5	4551.909	21962.67	$b\ {}^4F_{3\frac{1}{2}}-v\ {}^4G_{3\frac{1}{2}}$						
3	4551.52	21964.54	$a\ {}^4F_{4\frac{1}{2}}-y\ {}^4F_{3\frac{1}{2}}$						
4d	4551.03	21966.91	$b\ {}^3G_{4\frac{1}{2}}-v\ {}^3H_{3\frac{1}{2}}$						
3	4550.65	21968.74	$b\ {}^4P_{1\frac{1}{2}}-u\ {}^4D_{2\frac{1}{2}}$						
8	4547.847	21982.28	$\begin{cases} a\ {}^4D_{3\frac{1}{2}}-y\ {}^3F_{3\frac{1}{2}} \\ a\ {}^3F_{3\frac{1}{2}}-v\ {}^3D_{3\frac{1}{2}} \end{cases}$						
120, III	4546.820	21987.25	$a\ {}^4F_{3\frac{1}{2}}-z\ {}^4F_{3\frac{1}{2}}$	6		0.101	1.046	(1.029)	1.062
4	4543.72	22002.25							
12c	4542.797	22006.72	$a\ {}^4D_{3\frac{1}{2}}-z\ {}^4P_{2\frac{1}{2}}$	6		0.68*	2.90	(3.32)	2.48
4	4541.863	22011.24	$\begin{cases} b\ {}^4F_{3\frac{1}{2}}-v\ {}^4G_{3\frac{1}{2}} \\ a\ {}^4D_{1\frac{1}{2}}-y\ {}^3F_{2\frac{1}{2}} \\ a\ {}^3D_{2\frac{1}{2}}-w\ {}^4D_{1\frac{1}{2}} \end{cases}$						
4c	4540.10	22019.79							
5c	4537.59	22031.97	$a\ {}^4G_{3\frac{1}{2}}-v\ {}^4D_{2\frac{1}{2}}$						
2	4537.33	22033.24	$b\ {}^4F_{4\frac{1}{2}}-u\ {}^3F_{3\frac{1}{2}}$						
3d	4533.92	22049.81							
3c	4532.47	22056.86							
1	4530.43	22066.79	$a\ {}^3H_{4\frac{1}{2}}-v\ {}^4D_{1\frac{1}{2}}$						
6	4529.415	22071.74	$a\ {}^3P_{1\frac{1}{2}}-w\ {}^3D_{1\frac{1}{2}}$	4?		0	1.20	1.22	(1.21)
2	4529.250	22072.54	$b\ {}^4D_{2\frac{1}{2}}-t\ {}^4F_{3\frac{1}{2}}$						
20, V	4524.127	22097.54	$a\ {}^4F_{3\frac{1}{2}}-z\ {}^4P_{1\frac{1}{2}}$						
5	4523.727	22099.48	$a\ {}^4F_{4\frac{1}{2}}-z\ {}^4P_{2\frac{1}{2}}$						
200, III	4523.400	22101.04	$a\ {}^4F_{3\frac{1}{2}}-z\ {}^4F_{2\frac{1}{2}}$	6		0	0.409	(0.402)	0.416
6	4522.545	22105.26							
5	4520.836	22113.62	$a\ {}^4P_{2\frac{1}{2}}-z\ {}^4D_{1\frac{1}{2}}$						
2	4519.02	22122.51	$a\ {}^3P_{2\frac{1}{2}}-w\ {}^4D_{1\frac{1}{2}}$						
5	4516.914	22132.82	$a\ {}^3H_{4\frac{1}{2}}-w\ {}^3G_{4\frac{1}{2}}$?			0h	1.29h		
3c	4513.44	22149.86	$183_{3\frac{1}{2}}-t\ {}^4G_{3\frac{1}{2}}$						
2c	4512.65	22153.74	$b\ {}^3H_{4\frac{1}{2}}-u\ {}^3G_{3\frac{1}{2}}$						
7	4512.130	22156.29	$a\ {}^3G_{3\frac{1}{2}}-z\ {}^4G_{3\frac{1}{2}}$						
30c, V	4511.084	22161.42	$\begin{cases} b\ {}^3H_{3\frac{1}{2}}-t\ {}^3G_{3\frac{1}{2}} \\ b\ {}^4F_{3\frac{1}{2}}-v\ {}^4G_{3\frac{1}{2}} \end{cases}$	4		w	1.10d*	(1.04)	1.06
15, V	4508.409	22174.58	$b\ {}^4F_{4\frac{1}{2}}-v\ {}^4G_{3\frac{1}{2}}$	4		0	0.989	(1.120)	1.080
1	4507.24	22180.32	$a\ {}^4H_{4\frac{1}{2}}-w\ {}^4G_{3\frac{1}{2}}$						
10	4503.416	22199.16	$b\ {}^4F_{4\frac{1}{2}}-y\ {}^3H_{3\frac{1}{2}}$						
80, III	4503.040	22201.01	$a\ {}^4F_{3\frac{1}{2}}-y\ {}^4P_{2\frac{1}{2}}$	4	0.744	0.372	1.339	1.711	2.455
2c	4500.50	22213.54	$a\ {}^4H_{4\frac{1}{2}}-u\ {}^4F_{3\frac{1}{2}}$						
20, V	4499.803	22216.97	$a\ {}^3H_{4\frac{1}{2}}-w\ {}^3G_{3\frac{1}{2}}$	7b, 5?		0	0.94	(0.93)	0.92
5	4497.25	22229.59	$a\ {}^3G_{3\frac{1}{2}}-z\ {}^4G_{3\frac{1}{2}}$						
10	4494.545	22242.97	$a\ {}^4F_{3\frac{1}{2}}-z\ {}^4S_{1\frac{1}{2}}$						
4	4491.041	22260.34							
2	4490.35	22263.75	$a\ {}^3D_{3\frac{1}{2}}-w\ {}^4G_{3\frac{1}{2}}$						
2	4489.33	22268.81	$a\ {}^3D_{2\frac{1}{2}}-v\ {}^4F_{1\frac{1}{2}}$						
3d	4484.80	22291.30	$b\ {}^4P_{2\frac{1}{2}}-u\ {}^4D_{3\frac{1}{2}}$						
4	4482.877	22300.87	$a\ {}^4G_{3\frac{1}{2}}-w\ {}^3G_{3\frac{1}{2}}$						
8	4481.445	22307.99	$a\ {}^3D_{3\frac{1}{2}}-w\ {}^4D_{2\frac{1}{2}}$	6	0.11	0.27—	1.27w	1.21	1.33
4	4480.362	22313.39	$a\ {}^3H_{4\frac{1}{2}}-z\ {}^3H_{3\frac{1}{2}}$						
3c	4478.118	22324.57							
3	4477.585	22327.22	$a\ {}^4D_{3\frac{1}{2}}-z\ {}^4G_{3\frac{1}{2}}$						
4c	4476.498	22332.64	$a\ {}^4G_{3\frac{1}{2}}-y\ {}^3H_{3\frac{1}{2}}$						
4	4475.95	22335.38	$a\ {}^3H_{4\frac{1}{2}}-z\ {}^3H_{3\frac{1}{2}}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air Å	Wave No. vac. cm⁻¹	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
	•								
6	4475.278	22338.73				0	1.03		
2	4472.874	22350.74	$b\ {}^4F_{3/2}-y\ {}^3H_{5/2}$						
40c, IV	4472.536	22352.43	$a\ {}^4F_{3/2}-z\ {}^4F_{5/2}$	5		w	1.56—	(1.24)	1.31
50c, V	4471.292	22358.65	$a\ {}^2G_{7/2}-z\ {}^2F_{5/2}$	4		w	0.76	(1.10)	1.20
40c, IV	4469.714	22366.54	$b\ {}^4F_{3/2}-v\ {}^4G_{5/2}$	5	0.228	0.114	--	(0.402)	0.630
10	4469.322	22368.50	$a\ {}^4P_{1/2}-z\ {}^4D_{3/2}$ $a\ {}^2D_{3/2}-v\ {}^4F_{3/2}$						
1	4468.54	22372.42	$a\ {}^4S_{3/2}-v\ {}^4D_{1/2}$						
5	4466.421	22383.03	$a\ {}^4F_{3/2}-z\ {}^2D_{3/2}$						
3	4466.198	22384.15	$a\ {}^4H_{7/2}-w\ {}^4G_{5/2}$						
7	4465.926	22385.51	$a\ {}^2D_{3/2}-z\ {}^2D_{5/2}$						
4	4465.232	22388.99	$a\ {}^4F_{3/2}-z\ {}^2P_{3/2}$						
20, IV	4464.151	22394.41	$a\ {}^4F_{3/2}-y\ {}^2F_{5/2}$ $a\ {}^2H_{9/2}-y\ {}^2H_{11/2}$	6	0.09	0.39	1.35±	1.31	1.40
1	4461.49	22407.77	$b\ {}^4F_{3/2}-u\ {}^2F_{5/2}$						
20c, V	4460.423	22413.13	$a\ {}^2F_{3/2}-u\ {}^2D_{3/2}$	5		0	1.09	(1.13)	1.16
15c, V	4460.203	22414.23							
2	4459.671	22416.91	$a\ {}^2D_{3/2}-v\ {}^2F_{5/2}$						
15, V	4458.117	22424.72	$a\ {}^2F_{5/2}-u\ {}^2D_{5/2}$						
50, IV?	4457.424	22428.21	$a\ {}^4F_{3/2}-z\ {}^4F_{3/2}$	5		0	1.776	(1.029)	1.242
30, IV	4456.800	22431.35	$a\ {}^4F_{3/2}-z\ {}^4F_{5/2}$	5	0.718	0.363	--	(0.402)	1.120
4c	4456.331	22433.71	$b\ {}^2G_{7/2}-q\ {}^2F_{5/2}$						
3c	4454.68	22442.02	$a\ {}^4D_{7/2}-z\ {}^4G_{5/2}$						
6	4448.769	22471.84	$a\ {}^2G_{7/2}-z\ {}^2G_{9/2}$						
2	4448.06	22475.42							
100, IV	4447.184	22479.85	$a\ {}^4P_{3/2}-y\ {}^4P_{5/2}$	7b, 6		0	1.807	1.806	1.808
4	4446.232	22484.66	$a\ {}^4P_{1/2}-y\ {}^4P_{1/2}$						
12, V	4446.181	22484.92	$b\ {}^4F_{3/2}-v\ {}^4G_{3/2}$						
15c	4445.843	22486.63	$a\ {}^4D_{3/2}-z\ {}^4G_{3/2}$ $b\ {}^4F_{3/2}-u\ {}^2F_{5/2}$						
1	4444.26	22494.64	$a\ {}^2D_{3/2}-w\ {}^2F_{5/2}$						
2	4443.50	22496.97	$a\ {}^2P_{3/2}-z\ {}^2D_{3/2}$						
2	4443.302	22499.49	$a\ {}^4P_{1/2}-z\ {}^2F_{5/2}$						
1	4443.05	22500.77	$a\ {}^4P_{3/2}-y\ {}^4P_{3/2}$						
10c, V	4441.802	22507.09	$a\ {}^4D_{7/2}-z\ {}^4G_{7/2}$						
3c	4441.61	22508.06	$b\ {}^2G_{7/2}-t\ {}^2G_{7/2}$						
5	4440.435	22514.02	$b\ {}^4F_{3/2}-y\ {}^2H_{9/2}$						
1c	4439.38	22519.37	$b\ {}^4F_{3/2}-y\ {}^2S_{1/2}$ $b\ {}^2G_{9/2}-s\ {}^4G_{5/2}$						
7c	4437.918	22526.79	$b\ {}^2H_{9/2}-p\ {}^2H_{11/2}$						
100c, V	4437.218	22530.34				0	1.04		
5	4436.712	22532.91	$a\ {}^2F_{5/2}-p\ {}^2G_{9/2}$						
3	4435.919	22536.94							
3	4434.997	22541.62	$a\ {}^4F_{3/2}-z\ {}^4P_{3/2}$						
1	4433.895	22547.22							
3c	4433.496	22549.25	$b\ {}^4D_{7/2}-t\ {}^4F_{5/2}$						
2c	4432.912	22552.23	$b\ {}^2H_{9/2}-u\ {}^2G_{7/2}$						
1	4430.029	22566.90	$a\ {}^4G_{7/2}-z\ {}^4P_{5/2}$						
20c, V	4429.446	22569.87	$a\ {}^4P_{3/2}-z\ {}^2F_{5/2}$	4	0.48	0.23		1.60	1.12
2	4428.576	22574.30	$a\ {}^2D_{3/2}-w\ {}^4F_{5/2}$						
1	4427.866	22577.92	$a\ {}^4F_{5/2}-y\ {}^2F_{5/2}$						
20, V	4426.600	22583.92	$a\ {}^4P_{5/2}-z\ {}^4D_{5/2}$	6	0.117	0.293	1.726*	(1.896)	1.479
6c	4423.808	22598.33	$b\ {}^2H_{9/2}-t\ {}^2G_{9/2}$						
2	4421.305	22611.43	$a\ {}^2F_{5/2}-u\ {}^4D_{5/2}$						
30c, V	4420.637	22614.84	$a\ {}^6D_{7/2}-z\ {}^4P_{5/2}$						
10, V	4420.455	22615.78	$a\ {}^4F_{5/2}-y\ {}^2F_{5/2}$						
10, V	4419.839	22618.91	$a\ {}^4F_{5/2}-z\ {}^2D_{5/2}$						
40, IV	4419.448	22620.93	$a\ {}^4P_{1/2}-z\ {}^2P_{1/2}$	6	0.26	0.39	1.59	1.72	1.46
4	4418.166	22627.49							
6	4416.406	22636.51	$a\ {}^4G_{7/2}-v\ {}^4G_{5/2}$						
2	4415.080	22643.31	$a\ {}^2F_{5/2}-v\ {}^2G_{7/2}$						
8c	4414.879	22644.34	$a\ {}^4D_{7/2}-z\ {}^2F_{5/2}$ $a\ {}^2G_{9/2}-v\ {}^4F_{5/2}$						
2	4413.000	22653.98	$a\ {}^2H_{9/2}-v\ {}^4G_{5/2}$						
5	4412.184	22658.17	$a\ {}^2G_{7/2}-z\ {}^4G_{5/2}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ_{air} A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
15, V	4411.526	22661.55	$a\ ^3D_{3\frac{1}{2}}-z\ ^3F_{3\frac{1}{2}}$	5		0	1.11	(1.21)	1.18
2	4410.882	22664.86	$a\ ^4D_{3\frac{1}{2}}-v\ ^4F_{3\frac{1}{2}}$ $a\ ^3F_{3\frac{1}{2}}-u\ ^4D_{3\frac{1}{2}}$						
60, IV	4410.214	22668.20	$a\ ^4F_{3\frac{1}{2}}-x\ ^4D_{3\frac{1}{2}}$	6	2.42	1.21	1.42	2.63	0.21
10c	4406.546	22687.16	$a\ ^4F_{4\frac{1}{2}}-y\ ^4F_{3\frac{1}{2}}$						
1	4404.74	22696.46	$a\ ^4F_{3\frac{1}{2}}-z\ ^3F_{3\frac{1}{2}}$						
2	4403.925	22700.66	$a\ ^3D_{1\frac{1}{2}}-u\ ^4F_{2\frac{1}{2}}$						
7c	4402.055	22710.30							
10	4400.832	22716.62	$a\ ^4G_{4\frac{1}{2}}-v\ ^4G_{5\frac{1}{2}}$						
10c	4400.368	22719.01	$b\ ^3G_{3\frac{1}{2}}-t\ ^3G_{4\frac{1}{2}}$						
10	4397.036	22736.23	$a\ ^3H_{4\frac{1}{2}}-z\ ^3H_{3\frac{1}{2}}$	5		w	1.34—	(0.93)	1.00
1	4395.61	22743.60	$b\ ^4D_{1\frac{1}{2}}-z\ ^3P_{2\frac{1}{2}}$						
3	4394.229	22750.75	$a\ ^4F_{3\frac{1}{2}}-z\ ^3F_{3\frac{1}{2}}$						
30, V	4392.692	22758.71	$a\ ^3G_{4\frac{1}{2}}-w\ ^3F_{3\frac{1}{2}}$	5		0	1.14	(1.10)	1.08
4c	4391.89	22764.42	$a\ ^4D_{3\frac{1}{2}}-v\ ^4F_{3\frac{1}{2}}$						
7	4391.214	22768.37	$a\ ^3D_{2\frac{1}{2}}-w\ ^4D_{1\frac{1}{2}}$						
2	4389.496	22775.28	$a\ ^3F_{3\frac{1}{2}}-u\ ^4D_{2\frac{1}{2}}$						
30, V	4388.357	22781.19	$a\ ^4P_{1\frac{1}{2}}-x\ ^4D_{1\frac{1}{2}}$	6	0.283	0.427	1.890	1.731	1.448
15	4387.743	22784.38	$a\ ^4P_{2\frac{1}{2}}-y\ ^4P_{1\frac{1}{2}}$	4	1.012	0.506	1.162	2.680	1.668
4	4386.302	22791.87							
15c	4384.870	22799.31	$a\ ^4G_{4\frac{1}{2}}-v\ ^4G_{4\frac{1}{2}}$						
1	4383.70	22805.39	$b\ ^4F_{3\frac{1}{2}}-r\ ^3D_{2\frac{1}{2}}$						
9c	4382.856	22809.79	$a\ ^4F_{2\frac{1}{2}}-y\ ^4F_{2\frac{1}{2}}$ $a\ ^3D_{1\frac{1}{2}}-w\ ^4D_{1\frac{1}{2}}$						
7	4382.496	22811.66	$b\ ^4F_{1\frac{1}{2}}-u\ ^3F_{2\frac{1}{2}}$						
10c	4381.114	22818.86	$a\ ^3F_{3\frac{1}{2}}-r\ ^3G_{3\frac{1}{2}}$ $a\ ^3F_{3\frac{1}{2}}-u\ ^4D_{2\frac{1}{2}}$						
4c	4380.664	22821.20	$a\ ^4G_{4\frac{1}{2}}-u\ ^3F_{3\frac{1}{2}}$						
12	4379.825	22827.13	$a\ ^3G_{4\frac{1}{2}}-z\ ^4H_{5\frac{1}{2}}$						
30c, V	4377.958	22835.30	$a\ ^4G_{3\frac{1}{2}}-v\ ^4G_{3\frac{1}{2}}$	5	0.264	0.135	1.659	0.734	0.998
5	4377.823	22836.01							
4	4376.707	22841.83	$a\ ^3H_{4\frac{1}{2}}-y\ ^3H_{5\frac{1}{2}}$						
6	4375.246	22849.46	$a\ ^3D_{2\frac{1}{2}}-w\ ^3D_{1\frac{1}{2}}$ $a\ ^4G_{3\frac{1}{2}}-x\ ^4F_{3\frac{1}{2}}$						
12c	4374.789	22851.84	$a\ ^6D_{3\frac{1}{2}}-z\ ^4F_{4\frac{1}{2}}$						
15	4370.361	22875.00	$a\ ^4F_{4\frac{1}{2}}-y\ ^4F_{3\frac{1}{2}}$						
8	4369.616	22878.88	$a\ ^6D_{2\frac{1}{2}}-z\ ^4F_{3\frac{1}{2}}$						
80, IV?	4368.434	22885.00	$a\ ^3G_{4\frac{1}{2}}-x\ ^3G_{5\frac{1}{2}}$	6ur		0.079	1.006	1.105	1.267
9	4361.656	22920.65	$a\ ^4P_{2\frac{1}{2}}-z\ ^3P_{1\frac{1}{2}}$	4	1.198	0.599	0.856	2.653	1.455
5c	4360.504	22926.71	$b\ ^3G_{3\frac{1}{2}}-r\ ^3H_{4\frac{1}{2}}$						
40c, V	4359.865	22930.07	$a\ ^4D_{3\frac{1}{2}}-v\ ^4F_{4\frac{1}{2}}$	7b, 4		0	1.320	(1.300)	1.347
7	4356.847	22945.95	$b\ ^4F_{3\frac{1}{2}}-u\ ^3D_{2\frac{1}{2}}$	4		0	1.05	(1.12)	1.18
5c	4355.245	22954.39	$a\ ^6D_{3\frac{1}{2}}-u\ ^4F_{3\frac{1}{2}}$ $b\ ^4D_{1\frac{1}{2}}-t\ ^4D_{1\frac{1}{2}}$						
4	4354.784	22956.82							
6	4354.188	22959.96	$a\ ^4H_{4\frac{1}{2}}-z\ ^3H_{4\frac{1}{2}}$						
3	4354.006	22960.92	$a\ ^3P_{2\frac{1}{2}}-w\ ^3D_{3\frac{1}{2}}$						
20	4353.266	22964.83	$a\ ^6D_{3\frac{1}{2}}-z\ ^4F_{4\frac{1}{2}}$	5	0.310			(1.349)	1.239
2c	4352.243	22970.23	$a\ ^4D_{3\frac{1}{2}}-w\ ^4F_{3\frac{1}{2}}$						
40, IV?	4351.573	22973.76	$a\ ^3G_{3\frac{1}{2}}-z\ ^3G_{4\frac{1}{2}}$	6		0	0.896	(0.885)	0.908
9	4350.302	22980.47	$a\ ^3G_{3\frac{1}{2}}-v\ ^4F_{4\frac{1}{2}}$ $a\ ^4P_{1\frac{1}{2}}-y\ ^4P_{1\frac{1}{2}}$	4	0.163	0.082	...	(0.885)	1.048
30, V	4349.026	22987.21	$a\ ^4G_{4\frac{1}{2}}-y\ ^3H_{4\frac{1}{2}}$ $a\ ^4H_{5\frac{1}{2}}-w\ ^3G_{4\frac{1}{2}}$	4	0.115	0.062	0.650	1.283	1.168
40c, V	4348.652	22989.19	$a\ ^6D_{3\frac{1}{2}}-z\ ^4P_{2\frac{1}{2}}$	5ur		0w	1.862	(1.852)	1.470
8c	4347.312	22996.28	$a\ ^3F_{3\frac{1}{2}}-t\ ^3F_{3\frac{1}{2}}$						
10	4346.120	23002.58	$a\ ^4D_{1\frac{1}{2}}-v\ ^4F_{2\frac{1}{2}}$						
6c	4345.518	23005.77	$b\ ^3H_{4\frac{1}{2}}-t\ ^4G_{5\frac{1}{2}}$						
20d	4345.315	23006.84	$a\ ^6D_{2\frac{1}{2}}-z\ ^4P_{1\frac{1}{2}}$	4	1.719	0.860	0.748	3.327	1.608
25, V	4342.818	23020.07	$a\ ^4G_{3\frac{1}{2}}-v\ ^4G_{4\frac{1}{2}}$	7b, 4		0	1.067	(1.081)	1.076
7	4342.460	23021.97	$a\ ^4F_{4\frac{1}{2}}-y\ ^4F_{4\frac{1}{2}}$						
6	4338.698	23041.93	$a\ ^4G_{3\frac{1}{2}}-u\ ^3F_{3\frac{1}{2}}$						

TABLE 4.—*First spectrum of columbium* (Cb 1)—Continued

Intensity Arc	λ_{air} A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	7	8	10
12c	4337.561	23047.97	$a\ ^4D_{1\frac{1}{2}}-w\ ^4D_{1\frac{1}{2}}$	5		w	1.00h	(1.42)	1.35
6	4336.548	23053.36	$a\ ^2G_{4\frac{1}{2}}-z\ ^2I_{5\frac{1}{2}}$						
2h	4334.23	23065.68	$b\ ^4F_{3\frac{1}{2}}-y\ ^2G_{4\frac{1}{2}}$						
5	4332.428	23075.28	$a\ ^4H_{5\frac{1}{2}}-z\ ^2I_{6\frac{1}{2}}$ $b\ ^4P_{1\frac{1}{2}}-t\ ^4F_{2\frac{1}{2}}$						
1	4332.17	23076.66	$a\ ^2H_{4\frac{1}{2}}-u\ ^2F_{3\frac{1}{2}}$						
60, V	4331.371	23080.91	$a\ ^4P_{2\frac{1}{2}}-z\ ^4D_{1\frac{1}{2}}$	4	1.212	0.607	0.831	2.649	1.437
2	4331.252	23081.55	$a\ ^4G_{3\frac{1}{2}}-u\ ^2F_{3\frac{1}{2}}$						
20c, V	4329.732	23089.65	$a\ ^6D_{1\frac{1}{2}}-z\ ^4F_{1\frac{1}{2}}$						
4c	4329.47	23091.04	$b\ ^2G_{3\frac{1}{2}}-4009_{5\frac{1}{2}}$						
30c, V	4328.428	23096.61	$a\ ^4D_{2\frac{1}{2}}-u\ ^4F_{2\frac{1}{2}}$	6	0.323	0.797	--	(1.300)	1.033
25c, V	4327.385	23102.17	$a\ ^4D_{1\frac{1}{2}}-y\ ^4F_{1\frac{1}{2}}$	4	0.150	0.076	0.830	1.195	1.045
9	4326.540	23106.68	$a\ ^4F_{2\frac{1}{2}}-t\ ^2F_{3\frac{1}{2}}$ $a\ ^2G_{3\frac{1}{2}}-w\ ^2F_{3\frac{1}{2}}$						
100c, V	4326.320	23107.86	$a\ ^4D_{2\frac{1}{2}}-y\ ^4F_{1\frac{1}{2}}$	4	0.202	0.102	0.495	1.419	1.217
8	4323.466	23123.11	$a\ ^2G_{4\frac{1}{2}}-u\ ^4F_{3\frac{1}{2}}$	4		0	1.058	1.094	(1.115)
1	4322.148	23130.16	$b\ ^4F_{3\frac{1}{2}}-z\ ^2H_{5\frac{1}{2}}$						
3c	4321.88	23131.60							
6	4320.800	23137.38	$b\ ^4F_{2\frac{1}{2}}-u\ ^2D_{2\frac{1}{2}}$	5		0	0.868	(0.853)	0.831
1	4319.52	23144.23	$a\ ^4P_{1\frac{1}{2}}-z\ ^2P_{2\frac{1}{2}}$						
3	4319.147	23146.23	$a\ ^2G_{3\frac{1}{2}}-v\ ^4F_{2\frac{1}{2}}$						
10	4318.010	23152.33	$a\ ^2D_{2\frac{1}{2}}-w\ ^2D_{2\frac{1}{2}}$	7b, 6		0	1.207	(1.206)	1.208
12c	4316.476	23160.55	$a\ ^4G_{3\frac{1}{2}}-u\ ^2F_{3\frac{1}{2}}$ $b\ ^2G_{3\frac{1}{2}}-z\ ^4G_{3\frac{1}{2}}$						
1	4315.144	23167.70	$a\ ^4H_{4\frac{1}{2}}-z\ ^2H_{5\frac{1}{2}}$						
3	4314.262	23172.44	$a\ ^2G_{4\frac{1}{2}}-w\ ^4G_{5\frac{1}{2}}$						
10c	4313.887	23174.45	$b\ ^2H_{4\frac{1}{2}}-y\ ^2H_{5\frac{1}{2}}$						
25, V	4312.454	23182.15	$a\ ^6D_{2\frac{1}{2}}-z\ ^4F_{2\frac{1}{2}}$	6	0.596	1.483	1.351	1.649	1.053
4	4312.121	23183.95	$a\ ^2D_{1\frac{1}{2}}-z\ ^2D_{1\frac{1}{2}}$						
15	4311.695	23186.23	$a\ ^4F_{3\frac{1}{2}}-z\ ^2D_{2\frac{1}{2}}$						
20, V	4311.37	23187.98	$b\ ^4F_{4\frac{1}{2}}-y\ ^2G_{4\frac{1}{2}}$	6		w	1.077	(1.224)	0.930?
30c	4311.27	23188.52	$b\ ^4F_{3\frac{1}{2}}-u\ ^4D_{2\frac{1}{2}}$						
4	4310.826	23190.91	$a\ ^4H_{4\frac{1}{2}}-w\ ^2G_{5\frac{1}{2}}$						
20, V	4309.564	23197.70	$b\ ^4F_{3\frac{1}{2}}-u\ ^4D_{1\frac{1}{2}}$	4	0.197	0.100	0.628	1.120	1.317
20c	4308.692	23202.40	$a\ ^4D_{1\frac{1}{2}}-u\ ^4F_{1\frac{1}{2}}$	6	0.405	0.608	0.991	1.194	0.789
15c	4308.117	23205.49	$a\ ^4D_{2\frac{1}{2}}-w\ ^4D_{1\frac{1}{2}}$	5		0.092	1.36*	(1.360)	1.176
2c	4307.233	23210.25	$a\ ^4P_{2\frac{1}{2}}-z\ ^4S_{1\frac{1}{2}}$						
15	4306.283	23215.38	$a\ ^2D_{1\frac{1}{2}}-y\ ^2F_{2\frac{1}{2}}$	4	0.122	0.061	0.645	0.950	0.828
4c	4304.659	23224.13							
9c	4303.875	23228.36	$a\ ^4D_{1\frac{1}{2}}-w\ ^2F_{2\frac{1}{2}}$						
3	4302.435	23236.14	$b\ ^4F_{2\frac{1}{2}}-u\ ^2D_{1\frac{1}{2}}$						
4	4301.204	23242.79	$a\ ^2H_{4\frac{1}{2}}-y\ ^2H_{5\frac{1}{2}}$						
100, V	4300.989	23243.95	$a\ ^4P_{2\frac{1}{2}}-z\ ^4D_{2\frac{1}{2}}$ $a\ ^6D_{3\frac{1}{2}}-z\ ^4F_{3\frac{1}{2}}$	4	0.357	0.178	0.347	1.598	1.241
100, V	4299.596	23251.48	$a\ ^4P_{1\frac{1}{2}}-z\ ^4D_{1\frac{1}{2}}$	4	0.345	0.122	1.106	1.719	1.474
6	4297.920	23260.55	$a\ ^2G_{4\frac{1}{2}}-w\ ^2F_{3\frac{1}{2}}$ $b\ ^2G_{3\frac{1}{2}}-s\ ^4G_{3\frac{1}{2}}$						
20c, V	4296.159	23270.08				0.06	0.98		
15, V	4295.620	23273.00	$a\ ^4G_{4\frac{1}{2}}-y\ ^4G_{5\frac{1}{2}}$	4		0w	0.86	(1.23)	1.16
1	4295.253	23274.99	$a\ ^4H_{4\frac{1}{2}}-w\ ^2G_{5\frac{1}{2}}$						
1	4294.33	23279.99	$a\ ^4P_{2\frac{1}{2}}-y\ ^6P_{3\frac{1}{2}}$						
40c, V	4292.480	23290.03	$a\ ^4D_{2\frac{1}{2}}-w\ ^4F_{2\frac{1}{2}}$	4	0.162	0.081	0.83	1.361	1.199
20c, V	4292.035	23292.44	$a\ ^6D_{3\frac{1}{2}}-z\ ^6P_{3\frac{1}{2}}$						
1	4291.344	23296.19	$b\ ^4D_{2\frac{1}{2}}-w\ ^4P_{2\frac{1}{2}}$						
25, V	4291.195	23297.00	$a\ ^4D_{3\frac{1}{2}}-v\ ^4F_{4\frac{1}{2}}$	5			1.19	(0.06)	0.81
4	4289.85	23304.31							
30, V	4289.443	23306.52	$a\ ^4P_{2\frac{1}{2}}-z\ ^4H_{3\frac{1}{2}}$	4	0.716	0.359	-0.901	1.606	0.890
1	4288.429	23312.04	$a\ ^4H_{3\frac{1}{2}}-w^2\ G_{4\frac{1}{2}}$?						
6	4288.299	23312.73	$a\ ^2G_{3\frac{1}{2}}-u\ ^4F_{3\frac{1}{2}}$						
1	4288.12	23313.71	$a\ ^4H_{4\frac{1}{2}}-z\ ^2H_{5\frac{1}{2}}$						
60, IV	4286.987	23319.87	$a\ ^6D_{3\frac{1}{2}}-z\ ^4F_{4\frac{1}{2}}$	6	0.342	1.197	1.414	1.584	1.243
15, V	4286.216	23324.06	$b\ ^4F_{3\frac{1}{2}}-u\ ^4D_{2\frac{1}{2}}$ $b\ ^4D_{1\frac{1}{2}}-w\ ^4P_{1\frac{1}{2}}$	4	0.344	0.174	0.335	0.851	1.195
2	4285.842	23326.10	$a\ ^2P_{1\frac{1}{2}}-z\ ^2P_{2\frac{1}{2}}$						
1	4285.31	23328.99	$a\ ^2G_{3\frac{1}{2}}-z\ ^2I_{5\frac{1}{2}}$						
1h	4284.683	23332.41	$b\ ^4P_{2\frac{1}{2}}-r\ ^2F_{3\frac{1}{2}}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ_{air} A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
1h	4284.14	23335.36	$b\ ^2G_{4\frac{1}{2}}-s\ ^4G_{5\frac{1}{2}}$						
1	4283.906	23336.64	$a\ ^2P_{1\frac{1}{2}}-s\ ^4G_{2\frac{1}{2}}$						
3	4283.055	23341.27							
3	4282.968	23341.75							
2	4281.120	23351.82	$b\ ^4F_{3\frac{1}{2}}-u\ ^4D_{3\frac{1}{2}}$						
30, V	4280.586	23354.74	$a\ ^4P_{1\frac{1}{2}}-y\ ^6P_{1\frac{1}{2}}$	5		0	1.805	(1.721)	1.755
1	4280.38	23355.86	$b\ ^4F_{2\frac{1}{2}}-v\ ^2G_{3\frac{1}{2}}$						
8	4279.707	23359.54	$a\ ^4G_{3\frac{1}{2}}-y\ ^2H_{3\frac{1}{2}}$	4	0.131	0.061	--	(1.081)	0.930
5	4279.53	23360.50	$a\ ^4F_{4\frac{1}{2}}-y\ ^4F_{3\frac{1}{2}}$						
20	4279.49	23360.72	$\begin{cases} a\ ^4D_{1\frac{1}{2}}-w\ ^4D_{0\frac{1}{2}} \\ a\ ^4G_{2\frac{1}{2}}-y\ ^2D_{2\frac{1}{2}} \end{cases}$	5	1.148	0.574	1.770	1.196	0.948
20, V	4277.500	23371.59	$\begin{cases} a\ ^6D_{1\frac{1}{2}}-z\ ^3D_{1\frac{1}{2}} \\ a\ ^4H_{4\frac{1}{2}}-z\ ^3H_{3\frac{1}{2}} \end{cases}$	6	0.967	1.432	1.384	1.868	0.901
20	4274.692	23386.94	$a\ ^2G_{3\frac{1}{2}}-z\ ^2G_{3\frac{1}{2}}$	5	0.208	0.091	1.794	0.881	1.084
5	4273.357	23394.25	$\begin{cases} a\ ^2H_{4\frac{1}{2}}-y\ ^2H_{3\frac{1}{2}} \\ a\ ^4P_{2\frac{1}{2}}-y\ ^4G_{3\frac{1}{2}} \end{cases}$						
8	4272.972	23396.35	$a\ ^4H_{5\frac{1}{2}}-w\ ^2G_{4\frac{1}{2}}$						
4c	4272.027	23401.53	$a\ ^4D_{3\frac{1}{2}}-v\ ^2F_{3\frac{1}{2}}$						
50c, V	4270.691	23408.85	$a\ ^4D_{2\frac{1}{2}}-u\ ^4F_{1\frac{1}{2}}$	4	0.244	0.122	0.608	1.358	1.114
15, V	4268.667	23419.95	$a\ ^4D_{1\frac{1}{2}}-z\ ^4F_{1\frac{1}{2}}$	4	0.806	0.405	0.140	1.876	1.070
50, IV	4266.020	23434.48	$a\ ^4D_{1\frac{1}{2}}-u\ ^4F_{1\frac{1}{2}}$	4	0.155	0.078	0.807	1.195	1.040
4	4264.612	23442.22	$b\ ^4D_{0\frac{1}{2}}-s\ ^4F_{1\frac{1}{2}}$						
100, IV	4262.056	23456.28	$a\ ^6D_{4\frac{1}{2}}-z\ ^4F_{3\frac{1}{2}}$	6	0.216	0.977	1.444	1.552	1.336
20c, V	4261.717	23458.14	$a\ ^4D_{2\frac{1}{2}}-w\ ^4G_{3\frac{1}{2}}$						
5	4260.661	23463.95	$a\ ^2F_{3\frac{1}{2}}-z\ ^2F_{3\frac{1}{2}}$						
12c	4258.917	23473.56	$a\ ^2G_{4\frac{1}{2}}-w\ ^4G_{5\frac{1}{2}}$	6		0.80	1.16w	1.10	1.21
1	4258.120	23477.96	$b\ ^4F_{3\frac{1}{2}}-y\ ^4H_{3\frac{1}{2}}$						
5	4257.853	23479.43	$a\ ^2D_{2\frac{1}{2}}-v\ ^4D_{1\frac{1}{2}}$	4		0	1.187	1.205	(1.230)
4	4256.303	23487.98	$b\ ^4F_{2\frac{1}{2}}-u\ ^4D_{2\frac{1}{2}}$						
20c	4255.943	23489.97							
60c, V	4255.439	23492.75	$a\ ^4H_{3\frac{1}{2}}-z\ ^2H_{3\frac{1}{2}}$	5	0.134	0.063	--	(0.690)	0.824
30, V	4254.693	23496.87	$a\ ^4D_{0\frac{1}{2}}-u\ ^4F_{1\frac{1}{2}}$	5	0.714	0.357	1.156	0.085	0.799
50c, V	4253.695	23502.38	$a\ ^4D_{3\frac{1}{2}}-w\ ^4D_{2\frac{1}{2}}$	6		0.14*	1.345	(1.360)	1.330
80c, V	4252.977	23506.35	$a\ ^4D_{2\frac{1}{2}}-w\ ^4D_{1\frac{1}{2}}$	6		0.31*	1.385	(1.420)	1.361
20, IV	4249.457	23525.82	$a\ ^6D_{0\frac{1}{2}}-z\ ^2D_{1\frac{1}{2}}$	4	2.430	1.214	-0.317	3.328	0.898
3	4248.961	23528.56	$a\ ^2H_{4\frac{1}{2}}-v\ ^4G_{3\frac{1}{2}}$						
8	4248.658	23530.24	$a\ ^4D_{1\frac{1}{2}}-z\ ^4P_{1\frac{1}{2}}$						
4c	4247.680	23535.61	$b\ ^2G_{4\frac{1}{2}}-s\ ^2G_{3\frac{1}{2}}$						
20, V	4246.293	23543.35	$a\ ^4D_{1\frac{1}{2}}-w\ ^4D_{1\frac{1}{2}}$	7b, 6		0	1.196	(1.197)	1.195
1	4245.15	23549.69	$a\ ^2P_{1\frac{1}{2}}-x\ ^4P_{1\frac{1}{2}}$						
20c, V	4242.637	23563.63	$183_{3\frac{1}{2}}-s\ ^2G_{4\frac{1}{2}}$			0.26	1.06		
12	4241.453	23570.21	$a\ ^2G_{4\frac{1}{2}}-v\ ^2F_{3\frac{1}{2}}$	4		0w	0.89	(1.10)	1.16
4	4241.077	23572.30	$a\ ^2D_{2\frac{1}{2}}-v\ ^4D_{2\frac{1}{2}}$						
12c	4237.514	23590.45	$a\ ^4H_{4\frac{1}{2}}-z\ ^2H_{3\frac{1}{2}}$	6	0.12	0.65	1.07	1.13	1.01
4c	4236.998	23595.00	$a\ ^2G_{4\frac{1}{2}}-w\ ^4F_{3\frac{1}{2}}$						
25, IV	4231.954	23623.14	$a\ ^6D_{2\frac{1}{2}}-z\ ^4F_{2\frac{1}{2}}$	4	0.413	0.208	0.211	1.657	1.244
1	4231.624	23624.96	$a\ ^2G_{3\frac{1}{2}}-u\ ^4F_{2\frac{1}{2}}$						
20, V	4230.320	23632.24	$b\ ^4F_{1\frac{1}{2}}-u\ ^4D_{0\frac{1}{2}}$	5	0.375	0.188	0.564	0.206	0.021
25, V	4229.832	23634.97	$a\ ^4F_{4\frac{1}{2}}-y\ ^4F_{3\frac{1}{2}}$	7b, 6		0	1.333	(1.332)	1.334
1h	4229.570	23636.43	$b\ ^2G_{3\frac{1}{2}}-s\ ^4G_{4\frac{1}{2}}$						
100c, V	4229.154	23638.76	$a\ ^4D_{3\frac{1}{2}}-u\ ^4F_{3\frac{1}{2}}$	4	0.172	0.086	--	1.420	1.248
8c	4228.726	23641.15	$b\ ^2H_{4\frac{1}{2}}-q\ ^2F_{3\frac{1}{2}}$						
8	4227.514	23647.93	$a\ ^2D_{1\frac{1}{2}}-w\ ^2D_{1\frac{1}{2}}$	6	0.104	0.156	--	(0.953)	1.017
8c	4226.528	23653.44	$b\ ^2H_{4\frac{1}{2}}-t\ ^4G_{5\frac{1}{2}}$						
12d	4226.218	23655.18	$a\ ^4D_{0\frac{1}{2}}-w\ ^4D_{0\frac{1}{2}}$	6		--	0.690	0.114	(0.046)
1	4225.85	23657.24	$a\ ^4P_{2\frac{1}{2}}-y\ ^2D_{1\frac{1}{2}}$						
5c	4224.690	23663.73				0	0.91		
9	4222.670	23675.02	$a\ ^2G_{4\frac{1}{2}}-w\ ^4D_{2\frac{1}{2}}$						
150c, IV	4217.946	23701.57	$a\ ^6D_{3\frac{1}{2}}-y\ ^6F_{2\frac{1}{2}}$	5	0.279	0.140	2.284	1.586	1.307
100c, V	4214.732	23719.64	$a\ ^6D_{4\frac{1}{2}}-y\ ^6F_{3\frac{1}{2}}$	5	0.176	--	--	(1.549)	1.373
10c	4213.463	23726.79	$b\ ^2H_{4\frac{1}{2}}-s\ ^4G_{3\frac{1}{2}}$						
10c	4213.256	23727.95	$b\ ^4F_{2\frac{1}{2}}-u\ ^4D_{1\frac{1}{2}}$						
15, V	4212.535	23732.01	$a\ ^4H_{5\frac{1}{2}}-s\ ^4G_{4\frac{1}{2}}$	5		0	0.777	(0.690)	0.630

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest π	g_1	g_2
1	2	3	4	5	6	7	8	9	10
12, V	4212.042	23734.79	$b\ {}^4F_{3½}-y\ {}^4H_{3½}$	4	0.141	0.068	0.486	1.121	0.980
30, V	4208.156	23756.71	$a\ {}^6D_{1½}-z\ {}^8S_{3½}$	4	0.268	0.134	1.721	1.855	2.123
10	4206.127	23768.17	$b\ {}^4F_{3½}-y\ {}^4H_{3½}$						
120, IV	4205.308	23772.80	$a^6D_{3½}-y\ {}^6F_{1½}$ $a^2H_{5½}-x\ {}^2H_{3½}$	5	0.596	0.300	2.548	1.654	1.058
10	4204.322	23778.37	$a\ {}^2G_{3½}-e\ {}^4F_{3½}$						
1	4203.825	23781.18	$b\ {}^4D_{3½}-s\ {}^4F_{3½}$						
1	4203.732	23781.71	$a\ {}^2P_{1½}-u\ {}^2F_{2½}$						
7	4203.415	23783.50	$a\ {}^2F_{3½}-u\ {}^4G_{3½}$	6		0.045	0.853	0.862	0.844
6	4202.013	23791.44	$a\ {}^4G_{3½}-u\ {}^2D_{2½}$						
40, V	4201.519	23794.24	$a\ {}^4H_{4½}-z\ {}^2H_{5½}$	5		0w	1.132	(0.984)	1.011
7	4200.993	23797.21	$a\ {}^4P_{2½}-y\ {}^4G_{3½}$						
6	4199.189	23807.44	$a\ {}^3G_{4½}-u\ {}^4F_{3½}$						
2	4198.90	23809.08	$b\ {}^4D_{1½}-s\ {}^4F_{2½}$						
10	4198.847	23809.38	$a\ {}^4H_{4½}-e\ {}^4G_{3½}$	4		0	0.946	(0.984)	1.006
1	4198.672	23810.37	$a\ {}^4P_{2½}-y\ {}^2D_{2½}$ $b\ {}^4P_{2½}-w\ {}^4F_{1½}$						
30, IV	4198.510	23811.29	$a\ {}^6D_{2½}-z\ {}^4F_{1½}$	4	0.249	0.125	0.465	1.586	1.337
10c, V	4198.370	23812.08							
7c	4197.615	23816.36	$b\ {}^2G_{3½}-q\ {}^2F_{2½}$						
9c	4196.948	23820.15	$a\ {}^4H_{4½}-y\ {}^2H_{5½}$						
15, V	4195.660	23827.46	$a\ {}^2G_{3½}-s\ {}^2F_{2½}$	5		0w	1.026	0.872	(0.831)
4	4195.515	23828.28	$a\ {}^2F_{2½}-u\ {}^4G_{2½}$						
80, IV?	4195.096	23830.66	$a^6D_{1½}-y\ {}^6F_{½}$ $a^2H_{5½}-s\ {}^2G_{3½}$	5	2.465	1.233	3.097	1.864	−0.601
10c	4193.828	23837.87	$a^4D_{2½}-w\ {}^4D_{1½}$ $b\ {}^2G_{4½}-q\ {}^4F_{2½}$						
1	4193.42	23840.19	$a\ {}^4D_{1½}-w\ {}^4D_{½}$						
100c, IV	4192.065	23847.90	$a\ {}^6D_{2½}-z\ {}^6P_{2½}$	4	0.292	0.146	0.853	1.584	1.876
180c, IV	4190.889	23854.59	$a\ {}^6D_{4½}-z\ {}^6P_{3½}$	4	0.155	0.070	--	1.550	1.705
20c, V	4190.655	23855.92	$a\ {}^4D_{2½}-s\ {}^2F_{2½}$						
12	4189.997	23859.66	$b\ {}^2G_{4½}-s\ {}^2G_{3½}$						
3c	4189.59	23861.98							
3c	4189.250	23863.92	$b\ {}^4P_{2½}-w\ {}^4P_{2½}$?						
3c	4188.098	23870.48							
15, V	4186.104	23881.85	$a\ {}^2F_{3½}-t\ {}^4F_{3½}$	6	0.094	0.241	0.914	0.865	0.961
3	4185.66	23884.39	$b\ {}^4F_{3½}-s\ {}^2F_{2½}$						
50c, IV	4184.440	23891.35	$a\ {}^6D_{2½}-z\ {}^6P_{1½}$	4	0.730	0.366	0.559	1.654	2.383
2	4183.910	23894.38							
6	4181.784	23906.52	$a\ {}^4F_{3½}-y\ {}^4F_{3½}$						
15	4181.341	23909.06	$a\ {}^4H_{5½}-e\ {}^4G_{4½}$	5		w	1.39	1.13	(1.07)
2	4181.048	23910.73	$a\ {}^6D_{3½}-z\ {}^8S_{3½}$						
4	4179.826	23917.72	$a\ {}^4D_{1½}-z\ {}^2D_{1½}$						
12	4179.763	23918.08	$a\ {}^4G_{4½}-z\ {}^2H_{5½}$	4	0.116	0.056	0.621	1.261	1.145
1c	4177.554	23930.73	$a\ {}^4H_{3½}-v\ {}^4G_{3½}$						
4	4177.435	23931.41	$a\ {}^2D_{2½}-e\ {}^4D_{1½}$						
1h	4176.78	23935.17	$b\ {}^2G_{3½}-r\ {}^4F_{1½}$						
1	4176.166	23938.68	$a\ {}^2F_{1½}-u\ {}^4G_{1½}$						
5	4174.894	23945.98	$a\ {}^2H_{4½}-s\ {}^2G_{3½}$	7b		0	0.924	0.925	(0.925)
15	4174.342	23949.14	$a\ {}^4D_{1½}-s\ {}^2F_{2½}$	4	0.372	0.182	0.276	1.206	0.834
3	4174.047	23950.83	$a\ {}^2D_{1½}-w\ {}^2D_{1½}$						
12c	4173.955	23951.35	$b\ {}^2G_{4½}-p\ {}^2F_{2½}$						
1c	4172.34	23960.64	$a\ {}^4D_{2½}-w\ {}^4D_{2½}$						
3c	4170.909	23968.86	$b\ {}^4P_{1½}-t\ {}^2D_{2½}$						
30c, V	4169.565	23976.58	$a\ {}^4G_{4½}-u\ {}^4D_{3½}$	4	0.148	--	0.703	1.220	1.368
250c, IV	4168.122	23984.88	$a\ {}^6D_{3½}-y\ {}^6F_{3½}$	6	3.930	1.965	1.365	3.330	−0.600
3c	4167.44	23988.81							
6	4166.045	23996.84	$b\ {}^4F_{3½}-s\ {}^2F_{2½}$						
20	4165.850	23997.96	$a\ {}^4G_{3½}-u\ {}^4D_{2½}$						
4c	4165.330	24000.96							
300, III	4164.661	24004.81	$a\ {}^6D_{2½}-y\ {}^6F_{3½}$	6	0.349	0.879	1.479	1.654	1.305
250, III	4163.658	24010.60	$a\ {}^6D_{1½}-y\ {}^6F_{2½}$	6	0.802	1.203	1.462	1.863	1.061
40, V	4163.474	24011.66	$a\ {}^4F_{3½}-y\ {}^4F_{3½}$	6		--	1.261	(1.235)	1.287
12c	4162.817	24015.45	$a\ {}^2D_{2½}-y\ {}^2F_{2½}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm⁻¹	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
3c	4161.884	24020.83							
20c	4161.252	24024.48	$a\ ^3F_{3\frac{1}{2}}-t\ ^4F_{3\frac{1}{2}}$	6		0.081	1.162	1.150	1.173
8	4160.806	24027.05	$a\ ^4F_{3\frac{1}{2}}-y\ ^6D_{3\frac{1}{2}}$						
1	4159.49	24034.66	$b\ ^3G_{3\frac{1}{2}}-s\ ^4D_{3\frac{1}{2}}$						
20, V	4158.007	24043.23	$a\ ^4G_{3\frac{1}{2}}-u\ ^4D_{3\frac{1}{2}}$	4	0.235	0.118	0.494	1.081	1.316
5c	4155.36	24058.54							
6	4154.826	24061.64	$a\ ^4P_{1\frac{1}{2}}-y\ ^4G_{1\frac{1}{2}}$						
500, III	4152.575	24074.68	$a\ ^6D_{2\frac{1}{2}}-y\ ^6F_{3\frac{1}{2}}$	6	0.214	0.080	1.480	1.586	1.372
20c, V	4152.040	24077.78	$a\ ^6D_{2\frac{1}{2}}-z\ ^2D_{2\frac{1}{2}}$	5	0.285	--	--	(1.562)	1.297
100, V	4150.124	24088.90				--	0.97		
4	4149.721	24091.24	$a\ ^4F_{4\frac{1}{2}}-z\ ^2G_{3\frac{1}{2}}$ $b\ ^4D_{1\frac{1}{2}}-t\ ^4G_{2\frac{1}{2}}$						
15	4148.735	24096.96	$a\ ^2G_{3\frac{1}{2}}-w\ ^4F_{3\frac{1}{2}}$ $a\ ^4H_{3\frac{1}{2}}-y\ ^2H_{3\frac{1}{2}}$	5		0	1.06*		
6	4148.321	24099.37	$a\ ^2G_{4\frac{1}{2}}-w\ ^4G_{3\frac{1}{2}}$						
25c, IV?	4147.184	24105.97	$a\ ^4H_{5\frac{1}{2}}-v\ ^4G_{4\frac{1}{2}}$	5		h	1.571	1.223	(1.160)
1	4146.598	24109.38	$a\ ^2F_{3\frac{1}{2}}-x\ ^4H_{3\frac{1}{2}}$						
10	4146.000	24112.86	$a\ ^4H_{4\frac{1}{2}}-v\ ^4G_{3\frac{1}{2}}$	6		0.352	--	(0.984)	1.062
3c	4145.155	24117.77							
5c	4143.931	24124.90							
4c	4143.58	24126.94	$a\ ^2P_{0\frac{1}{2}}-y\ ^2P_{1\frac{1}{2}}$						
80c, IV	4143.201	24129.15	$a\ ^6D_{1\frac{1}{2}}-z\ ^6P_{1\frac{1}{2}}$	6	0.519	0.779	2.123	1.863	2.382
9	4142.243	24134.73	$a\ ^4H_{4\frac{1}{2}}-u\ ^2F_{3\frac{1}{2}}$						
4	4141.32	24140.11							
400c, IV	4139.702	24149.54	$a\ ^6D_{3\frac{1}{2}}-y\ ^6F_{4\frac{1}{2}}$	6	0.139	0.681	1.506	1.576	1.437
90c, IV	4139.430	24151.13	$a\ ^6D_{3\frac{1}{2}}-z\ ^6P_{2\frac{1}{2}}$	6	0.221	0.552	--	(1.652)	1.873
6	4139.088	24153.12	$b\ ^4D_{2\frac{1}{2}}-s\ ^4F_{1\frac{1}{2}}$						
10c	4138.300	24157.72	$b\ ^3G_{4\frac{1}{2}}-r\ ^3G_{3\frac{1}{2}}$						
12c	4137.500	24161.87	$a\ ^4G_{3\frac{1}{2}}-u\ ^4D_{2\frac{1}{2}}$						
200, III	4137.090	24164.79	$a\ ^6D_{0\frac{1}{2}}-y\ ^6F_{1\frac{1}{2}}$	4	2.197	1.135	0.073	3.368	1.171
4	4135.57	24173.67	$a\ ^2H_{4\frac{1}{2}}-x\ ^2H_{3\frac{1}{2}}$						
10	4135.423	24174.53	$b\ ^4F_{2\frac{1}{2}}-s\ ^2F_{2\frac{1}{2}}$	6		0	0.846	(0.852)	0.840
6	4134.985	24177.09	$a\ ^4H_{3\frac{1}{2}}-u\ ^2F_{2\frac{1}{2}}$						
30, IV	4134.592	24179.39	$a\ ^2P_{1\frac{1}{2}}-y\ ^2D_{2\frac{1}{2}}$	4		0	1.144	1.171	(1.100)
1	4134.33	24180.92							
5h	4133.40	24186.36							
3c	4132.175	24193.53							
2	4131.74	24196.08	$a\ ^4P_{2\frac{1}{2}}-x\ ^4F_{3\frac{1}{2}}$						
3	4131.60	24196.90	$a\ ^4G_{2\frac{1}{2}}-s\ ^2G_{3\frac{1}{2}}$						
6	4131.53	24197.31	$a\ ^4G_{3\frac{1}{2}}-u\ ^4D_{3\frac{1}{2}}$						
150c, V	4129.931	24206.67				--	1.08		
100c, V	4129.430	24209.61	$a\ ^6D_{3\frac{1}{2}}-z\ ^6P_{3\frac{1}{2}}$	6	0.131	0.476	1.635	1.570	1.701
4	4129.000	24212.13	$a\ ^4D_{2\frac{1}{2}}-x\ ^2D_{2\frac{1}{2}}$						
2	4128.654	24214.16	$a\ ^2H_{5\frac{1}{2}}-y\ ^4H_{4\frac{1}{2}}$						
1	4127.69	24219.82	$a\ ^2F_{3\frac{1}{2}}-x\ ^4H_{4\frac{1}{2}}$						
12c	4127.458	24221.18	$b\ ^3G_{3\frac{1}{2}}-411_{3\frac{1}{2}}$	6		0.06	--	(0.90)	0.88
8c	4126.903	24224.44				0	1.12		
12	4125.573	24232.24	$a\ ^4F_{3\frac{1}{2}}-y\ ^6D_{3\frac{1}{2}}$						
20c, V	4125.243	24234.18	$a\ ^4H_{3\frac{1}{2}}-v\ ^4G_{3\frac{1}{2}}$						
400, III	4123.812	24242.59	$a\ ^6D_{1\frac{1}{2}}-y\ ^6F_{2\frac{1}{2}}$	4	0.558	0.282	0.468	1.863	1.305
15, V	4122.804	24248.52	$a\ ^4H_{3\frac{1}{2}}-y\ ^2H_{3\frac{1}{2}}$	5	0.174	--	--	1.129	(0.955)
3c	4121.000	24258.78							
2	4117.824	24277.85	$a\ ^2D_{1\frac{1}{2}}-s\ ^4D_{1\frac{1}{2}}$						
50, III	4116.895	24283.32	$a\ ^6D_{0\frac{1}{2}}-z\ ^6P_{1\frac{1}{2}}$	4	0.943	0.473	1.910	3.325	2.382
5	4116.401	24286.24	$a\ ^4F_{1\frac{1}{2}}-y\ ^4F_{1\frac{1}{2}}$						
2	4116.274	24286.99	$b\ ^4F_{3\frac{1}{2}}-s\ ^2F_{3\frac{1}{2}}$						
6	4114.155	24299.50	$a\ ^2F_{2\frac{1}{2}}-r\ ^2F_{2\frac{1}{2}}$						
25, V	4113.941	24300.76	$a\ ^4H_{4\frac{1}{2}}-y\ ^2H_{3\frac{1}{2}}$	5	0.132	0.066	1.717	0.990	1.122
6	4113.348	24304.26	$b\ ^4F_{3\frac{1}{2}}-t\ ^4F_{3\frac{1}{2}}$						
1	4112.49	24309.33	$a\ ^2G_{3\frac{1}{2}}-u\ ^4F_{4\frac{1}{2}}$						
20c, V	4112.130	24311.46	$b\ ^2H_{4\frac{1}{2}}-411_{3\frac{1}{2}}$	5		0.09	1.02	0.827	(0.76)
2	4110.12	24323.35	$a\ ^4G_{3\frac{1}{2}}-y\ ^4H_{3\frac{1}{2}}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	7	8	10
4	4109.88	24324.77	$a\ {}^4P_{1/2}-y\ {}^2D_{1/2}$						
3	4108.71	34331.70							
1h	4107.67	24337.86	$b\ {}^4D_{3/2}-z\ {}^4F_{1/2}$						
3c	4107.05	24341.53							
6	4106.778	24343.14	$a\ {}^4F_{3/2}-y\ {}^4F_{1/2}$						
12	4106.173	24346.73	$a\ {}^4D_{3/2}-w\ {}^2D_{3/2}$	4	0.149	0.382	1.287	1.362	1.213
1	4105.47	24350.90	$a\ {}^2F_{3/2}-x\ {}^4H_{1/2}$						
1	4104.71	24355.41	$b\ {}^4D_{3/2}-t\ {}^2G_{1/2}$						
3	4103.74	24361.17	$b\ {}^4F_{3/2}-u\ {}^4G_{1/2}$						
600c, III	4100.918	24377.93	$a\ {}^4D_{3/2}-y\ {}^4F_{3/2}$ $b\ {}^4F_{3/2}-t\ {}^4F_{1/2}$	4	0.271	0.139	0.716	1.665	1.394
80, IV	4100.389	24381.07	$a\ {}^4D_{3/2}-z\ {}^2D_{1/2}$	6	0.370	--	--	(1.652)	1.282
3	4100.30	24381.60	$a\ {}^4D_{1/2}-w\ {}^2D_{1/2}$						
1	4100.11	24382.73	$a\ {}^4H_{3/2}-v\ {}^4G_{1/2}$						
30, IV	4099.067	24388.93	$a\ {}^4D_{1/2}-z\ {}^4P_{1/2}$	5		0	1.884	(1.863)	1.871
5h	4098.87	24390.11							
10	4098.220	24393.88	$b\ {}^4F_{1/2}-t\ {}^4F_{1/2}$	5		w	1.404	(1.224)	1.173
10c	4097.63	24397.49	$b\ {}^2H_{1/2}-q\ {}^4F_{1/2}$?						
5h	4096.314	24405.33							
7	4095.553	24409.86	$a\ {}^2F_{1/2}-r\ {}^2F_{1/2}$	6		--	0.864	0.848	(0.880)
8h	4095.082	24412.67							
1	4094.31	24417.27	$a\ {}^2D_{1/2}-v\ {}^4G_{1/2}$						
6	4094.095	24418.55	$b\ {}^4D_{1/2}-t\ {}^4G_{1/2}$?			--	1.18		
6	4093.926	24419.56	$b\ {}^4F_{1/2}-t\ {}^4F_{1/2}$ $b\ {}^2H_{1/2}-s\ {}^2G_{1/2}$						
6h	4092.536	24427.86							
3	4091.67	24433.03	$a\ {}^2D_{1/2}-v\ {}^4D_{1/2}$						
3c	4090.60	24439.42							
20, III	4090.163	24442.03	$a\ {}^4G_{3/2}-y\ {}^4H_{1/2}$	4		0h	0.580	(0.742)	0.696
2	4088.443	24452.31	$a\ {}^4H_{1/2}-y\ {}^2H_{1/2}$						
6	4087.048	24460.66	$a\ {}^2F_{1/2}-t\ {}^2D_{1/2}$	4		0	0.810	(0.860)	0.893
9	4086.630	24463.16	$a\ {}^2D_{1/2}-y\ {}^2P_{1/2}$	5	0.509	0.254	1.212	0.957	0.448
4	4084.951	24473.21	$a\ {}^2H_{1/2}-y\ {}^4H_{1/2}$						
40, IV	4084.861	24473.75	$a\ {}^4F_{1/2}-y\ {}^4F_{1/2}$	6		0.115	1.070	1.047	1.093
10, V	4084.177	24477.85	$a\ {}^4P_{1/2}-y\ {}^2D_{1/2}$	4	0.371	0.189	0.792	1.719	1.348
5	4083.776	24480.25	$a\ {}^4F_{1/2}-y\ {}^2D_{1/2}$						
1000c, III	4079.726	24504.56	$a\ {}^6D_{3/2}-y\ {}^4F_{1/2}$	4	0.158	0.079	0.865	1.576	1.418
7c	4078.60	24511.32	$a\ {}^4G_{1/2}-u\ {}^4G_{1/2}$ $a\ {}^2P_{1/2}-u\ {}^2D_{1/2}$						
6	4078.345	24512.85	$a\ {}^6D_{3/2}-z\ {}^6P_{1/2}$						
4	4077.405	24518.50							
15c	4077.09	24520.40	$b\ {}^4D_{3/2}-r\ {}^4F_{1/2}$	5		0	0.67	(0.04)	0.46
8	4076.09	24526.42	$a\ {}^4F_{3/2}-z\ {}^2G_{1/2}$						
6	4073.641	24541.16	$b\ {}^4F_{3/2}-u\ {}^4G_{1/2}$						
6	4073.513	24541.93	$b\ {}^4D_{1/2}-r\ {}^4F_{1/2}$						
2	4072.13	24550.27	$a\ {}^2F_{3/2}-t\ {}^2D_{1/2}$						
3d	4071.54	24553.82	$b\ {}^4P_{3/2}-x\ {}^2P_{3/2}$						
20, V	4070.965	24557.29	$b\ {}^4F_{3/2}-t\ {}^4F_{1/2}$	6		0.192	1.136	1.108	1.163
6c	4070.040	24562.87							
40c, V	4068.258	24573.63	$a\ {}^4H_{1/2}-y\ {}^2H_{1/2}$	5	0.267	0.134	--	(0.690)	0.957
15, V	4067.159	24580.27	$a\ {}^4G_{3/2}-y\ {}^4H_{1/2}$	4	0.097	0.050	0.621	1.059	0.962
12	4066.120	24586.55	$a\ {}^4H_{1/2}-v\ {}^4G_{1/2}$	5	0.176	0.088	--	(0.984)	1.160
10	4064.802	24594.52	$b\ {}^4F_{3/2}-t\ {}^4F_{1/2}$	6	0.108	0.271	--	0.854	0.962
2	4062.21	24610.22	$a\ {}^2P_{1/2}-u\ {}^2D_{1/2}$						
10	4061.542	24614.26	$a\ {}^4F_{3/2}-y\ {}^2D_{1/2}$						
4	4061.427	24614.96	$b\ {}^4F_{3/2}-u\ {}^4G_{1/2}$ $a\ {}^2H_{1/2}-y\ {}^2H_{1/2}$						
9	4061.255	24616.00	$a\ {}^2D_{3/2}-v\ {}^4G_{1/2}$						
40c, IV?	4060.800	24618.76	$a\ {}^4D_{1/2}-z\ {}^2D_{1/2}$						
4	4060.37	24621.37	$a\ {}^4G_{1/2}-x\ {}^2F_{1/2}$						
10	4060.32	24621.67	$a\ {}^4F_{3/2}-x\ {}^4D_{1/2}$						
5	4059.85	24624.52	$a\ {}^4P_{1/2}-y\ {}^2D_{1/2}$						
40, V	4059.498	24626.66	$a\ {}^2P_{3/2}-v\ {}^2D_{1/2}$	5	0.296	0.148	1.090	0.646	0.942
2000c, III	4058.933	24630.08	$a\ {}^6D_{3/2}-y\ {}^6F_{3/2}$ $a\ {}^2D_{3/2}-x\ {}^4F_{1/2}$	4	0.113	0.055	0.942	1.563	1.450

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ_{air} A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
6c	4057.267	24640.20	$b\ ^4D_{3½}-s\ ^4G^0_{5½}$						
8	4056.941	24642.18	$b\ ^4F_{3½}-u\ ^4D^0_{3½}$ $b\ ^4F_{3½}-z\ ^4H^0_{3½}$						
4c	4055.854	24648.78							
2	4055.426	24651.38	$b\ ^4F_{3½}-u\ ^4G^0_{3½}$						
8c	4055.186	24652.84	$b\ ^3G_{3½}-s\ ^3G^0_{3½}$	6	0.062	0.186	0.928	0.897	0.959
6	4053.161	24665.16	$a\ ^3F_{3½}-t\ ^3D^0_{3½}$						
6c	4052.132	24671.42	$a\ ^4D_{3½}-s\ ^4D^0_{3½}$						
25, V	4051.513	24675.19	$a\ ^3G_{4½}-z\ ^3I^0_{5½}$	4	0.163	0.082	0.208	1.103	0.940
6	4051.001	24678.31	$a\ ^4F_{3½}-y\ ^6D^0_{3½}$						
20, IV?	4049.759	24685.88	$b\ ^4F_{4½}-t\ ^4F^0_{4½}$	6		0.060	1.254	1.246	1.262
3	4048.95	24690.81							
3	4048.01	24696.54	$b\ ^3G_{3½}-416^0_{3½}$						
4h	4046.27	24707.16							
12, V	4044.712	24716.68	$a\ ^3F_{3½}-r\ ^3F^0_{3½}$	6		0.076	1.133	1.120	1.146
1	4044.58	24717.49	$b\ ^3H_{3½}-r\ ^3G^0_{3½}$						
25, V	4044.103	24720.40	$b\ ^4F_{4½}-x\ ^4H^0_{5½}$	6	0.237	1.076	2.225	1.231	0.994
10c	4043.169	24726.11	$b\ ^4D_{3½}-s\ ^4F^0_{4½}$						
10	4042.572	24729.76	$a\ ^4G_{3½}-s\ ^3F^0_{4½}$	5	0.229	0.114	--	(1.081)	0.852
1	4041.39	24737.00	$a\ ^4F_{4½}-y\ ^6D^0_{3½}$						
3	4040.618	24741.72	$a\ ^3P_{2½}-z\ ^4P^0_{1½}$						
8	4040.468	24742.64	$a\ ^4F_{3½}-z\ ^3G^0_{3½}$ $b\ ^4D_{3½}-r\ ^4F^0_{3½}$						
60c, V	4039.530	24748.39	$a\ ^4G_{3½}-u\ ^4G^0_{3½}$	6		w	1.256	(1.260)	1.262
15, V	4039.094	24751.06	$a\ ^4H_{5½}-z\ ^3H^0_{5½}$ $a\ ^4P_{2½}-y\ ^2F^0_{2½}$	5	0.12	0.062	--	(1.22)	1.10
8h	4038.172	24756.71							
4h	4037.356	24761.72	$a\ ^4P_{1½}-z\ ^5S^0_{2½}$						
12	4035.923	24770.51	$b\ ^4D_{1½}-r\ ^4F^0_{1½}$						
10	4035.095	24775.59	$a\ ^3F_{2½}-t\ ^3D^0_{2½}$	6	0.215	0.540	0.967	0.860	1.075
6h	4034.527	24779.08							
1	4034.178	24781.22	$a\ ^4P_{2½}-x\ ^4F^0_{1½}$						
40, V	4033.195	24787.26	$a\ ^4F_{1½}-y\ ^4F^0_{1½}$	6	0.075	0.102	0.429	0.392	0.467
150, IV	4032.524	24791.39	$a\ ^4F_{4½}-y\ ^4D^0_{3½}$	4	0.092	0.046	1.002	(1.330)	1.422
10h	4030.348	24804.77							
6	4029.223	24811.69							
4d	4028.865	24813.90							
15c, V	4027.972	24819.40	$a\ ^4G_{3½}-t\ ^4F^0_{3½}$	7b		0	1.261	(1.260)	1.259
12, V	4027.311	24823.47	$b\ ^4F_{1½}-t\ ^4F^0_{1½}$	6	0.118	0.183	0.466	0.408	0.526
4	4026.71	24827.18	$a\ ^3F_{2½}-r\ ^3F^0_{2½}$						
5c	4026.41	24829.03	$a\ ^4D_{2½}-s\ ^4D^0_{2½}$						
4	4025.88	24832.30	$b\ ^4F_{3½}-r\ ^3F^0_{3½}$						
2	4024.26	24842.29	$a\ ^4G_{3½}-s\ ^3F^0_{3½}$						
2	4023.41	24847.54	$b\ ^4F_{3½}-t\ ^4F^0_{3½}$						
8	4023.275	24848.38	$a\ ^4G_{3½}-s\ ^3F^0_{2½}$	6		0.227	0.792	(0.742)	0.843
12, V	4023.141	24849.20	$b\ ^4F_{3½}-t\ ^4F^0_{4½}$	5	0.134	0.058	1.733	1.143	1.277
9c	4022.387	24853.86	$a\ ^4G_{3½}-x\ ^4H^0_{3½}$						
4	4021.016	24862.33	$a\ ^3D_{2½}-u\ ^3F^0_{1½}$						
6	4020.233	24867.18							
2	4019.13	24874.00	$a\ ^3H_{4½}-y\ ^3H^0_{4½}$						
2	4017.793	24882.28	$a\ ^3D_{2½}-x\ ^5S^0_{2½}$						
15, V	4017.558	24883.73	$b\ ^4F_{3½}-x\ ^4H^0_{4½}$	4	0.114	0.057	0.593	1.105	0.991
10h	4016.070	24892.95							
3	4015.748	24894.95	$b\ ^4D_{2½}-r\ ^4F^0_{2½}$						
6c	4014.922	24900.07	$b\ ^4F_{4½}-u\ ^4G^0_{4½}$	5	0.435	0.218	--	(0.402)	0.837
3	4014.646	24901.78							
4	4013.942	24906.15	$a\ ^3G_{4½}-w\ ^3G^0_{4½}$						
20, V	4013.268	24910.33	$b\ ^3G_{3½}-p\ ^3F^0_{2½}$	5		0	0.906	(0.88)	0.86
4c	4013.101	24911.37							
6	4012.056	24917.86	$a\ ^4F_{1½}-y\ ^4F^0_{2½}$						
20, V	4009.707	24932.45	$b\ ^4F_{3½}-x\ ^4H^0_{4½}$	4p	0.145	0.074	0.335	0.843	0.698
1	4009.533	24933.54	$a\ ^3F_{3½}-w\ ^3H^0_{4½}$						

TABLE 4.—*First spectrum of columbium* (Cb 1)—Continued

Intensity Arc	λ air A	Wave No. vac. cm⁻¹	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
30, V	4008.286	24941.29	$a\ ^5D_{3\frac{1}{2}} - u\ ^3F_{3\frac{1}{2}}$	4	0.101	0.050	0.865	1.218	1.117
4d	4006.05	24955.22	$b\ ^3G_{3\frac{1}{2}} - q\ ^4F_{3\frac{1}{2}}$						
4	4005.915	24956.06							
2	4005.13	24960.95	$a\ ^4G_{3\frac{1}{2}} - s\ ^3F_{3\frac{1}{2}}$						
4h	4002.25	24978.91							
15c, V	4001.135	24985.87	$a\ ^4G_{4\frac{1}{2}} - u\ ^4G_{3\frac{1}{2}}$						
1	4000.446	24990.17	$a\ ^3G_{4\frac{1}{2}} - w\ ^3G_{3\frac{1}{2}}$						
1	3999.868	24993.78	$a\ ^3P_{2\frac{1}{2}} - x\ ^5S_{1\frac{1}{2}}$						
40, V	3999.182	24998.07	$b\ ^4F_{4\frac{1}{2}} - x\ ^4H_{3\frac{1}{2}}$	4	0.127	0.061	0.517	1.216	1.089
7	3998.447	25002.67	$b\ ^4D_{3\frac{1}{2}} - q\ ^2F_{3\frac{1}{2}}$						
4	3998.23	25004.02	$a\ ^4H_{4\frac{1}{2}} - s\ ^3G_{3\frac{1}{2}}$						
2d	3997.780	25006.83	$b\ ^4D_{3\frac{1}{2}} - s\ ^4D_{3\frac{1}{2}}$						
4h	3997.377	25009.36							
4	3997.157	25010.74							
1	3996.95	25012.03	$b\ ^3G_{3\frac{1}{2}} - q\ ^4F_{3\frac{1}{2}}$						
3	3995.588	25020.55	$a\ ^2H_{4\frac{1}{2}} - u\ ^4G_{3\frac{1}{2}}$						
6	3994.420	25027.87	$a\ ^4H_{3\frac{1}{2}} - x\ ^3H_{3\frac{1}{2}}$						
1	3993.36	25034.52	$b\ ^4D_{1\frac{1}{2}} - s\ ^4D_{2\frac{1}{2}}$						
4	3992.165	25042.01	$a\ ^3F_{3\frac{1}{2}} - x\ ^3P_{1\frac{1}{2}}$						
40c, V	3991.677	25045.07			0.19	0.10			
1	3990.926	25049.78	$a\ ^4F_{4\frac{1}{2}} - y\ ^2G_{3\frac{1}{2}}$						
6	3990.665	25051.42	$a\ ^4G_{3\frac{1}{2}} - u\ ^4G_{3\frac{1}{2}}$						
20c	3988.158	25067.17	$b\ ^2H_{4\frac{1}{2}} - s\ ^2G_{3\frac{1}{2}}$			0h	1.188	(1.04)	1.34?
4c	3986.17	25079.67	$b\ ^4D_{3\frac{1}{2}} - r\ ^4F_{3\frac{1}{2}}$						
6c	3985.18	25085.90	$a\ ^4H_{3\frac{1}{2}} - p\ ^2G_{3\frac{1}{2}}$						
4	3985.074	25086.57	$a\ ^2G_{4\frac{1}{2}} - z\ ^3H_{3\frac{1}{2}}$						
6	3984.810	25088.23	$b\ ^4D_{3\frac{1}{2}} - s\ ^4G_{3\frac{1}{2}}$						
10c	3982.055	25105.59	$b\ ^4F_{4\frac{1}{2}} - y\ ^2I_{5\frac{1}{2}}$	4	0.269	0.137	--	(1.224)	0.955
60c, IV	3980.483	25115.50	$a\ ^6D_{4\frac{1}{2}} - y\ ^4F_{3\frac{1}{2}}$	5	0.304	0.151	2.614	1.552	1.248
10, V	3979.370	25122.53	$b\ ^4F_{3\frac{1}{2}} - r\ ^2F_{2\frac{1}{2}}$	6		w	0.864	(0.854)	0.874
4	3978.909	25125.44	$a\ ^4H_{3\frac{1}{2}} - p\ ^2G_{3\frac{1}{2}}$						
12, V	3978.753	25126.42	$a\ ^4F_{3\frac{1}{2}} - x\ ^5D_{3\frac{1}{2}}$						
20c, V	3977.940	25131.56	$a\ ^4G_{3\frac{1}{2}} - x\ ^4H_{3\frac{1}{2}}$						
15c, V	3976.677	25139.54	$b\ ^4D_{3\frac{1}{2}} - t\ ^4G_{3\frac{1}{2}}$						
6h	3975.20	25148.88							
2d	3973.87	25157.30	$a\ ^4D_{3\frac{1}{2}} - v\ ^4G_{3\frac{1}{2}}$						
20c	3973.624	25158.85	$b\ ^2H_{4\frac{1}{2}} - p\ ^2F_{3\frac{1}{2}}$						
40c, V	3972.512	25165.89	$a\ ^4G_{4\frac{1}{2}} - u\ ^4G_{3\frac{1}{2}}$			w	1.51		
15, V	3971.932	25169.57	$a\ ^4F_{4\frac{1}{2}} - z\ ^5D_{3\frac{1}{2}}$						
20, V	3971.852	25170.08	$a\ ^4G_{3\frac{1}{2}} - u\ ^4G_{3\frac{1}{2}}$						
1	3971.35	25173.26	$b\ ^4F_{3\frac{1}{2}} - t\ ^3D_{1\frac{1}{2}}$						
12, V	3970.650	25177.70	$a\ ^4F_{3\frac{1}{2}} - z\ ^3G_{3\frac{1}{2}}$	4	0.163	0.085	--	(1.235)	1.072
4h	3970.10	25181.18							
5c	3968.465	25191.55	$b\ ^4D_{3\frac{1}{2}} - s\ ^4D_{1\frac{1}{2}}$						
7c	3968.32	25192.48							
1	3967.61	25196.99	$a\ ^4D_{1\frac{1}{2}} - y\ ^3P_{2\frac{1}{2}}$						
1	3967.441	25198.06	$b\ ^4F_{4\frac{1}{2}} - t\ ^3D_{2\frac{1}{2}}$						
150, V	3966.246	25205.65	$a\ ^4F_{3\frac{1}{2}} - y\ ^4D_{2\frac{1}{2}}$	4		--	1.016	(1.235)	1.322
25, V	3966.094	25206.61	$a\ ^4G_{3\frac{1}{2}} - u\ ^4G_{2\frac{1}{2}}$						
40, IV	3965.692	25209.17	$a\ ^4P_{2\frac{1}{2}} - y\ ^5S_{1\frac{1}{2}}$	4	0.365	0.182	1.049	1.596	1.961
7	3964.665	25215.71	$a\ ^2D_{2\frac{1}{2}} - v\ ^4G_{2\frac{1}{2}}$						
3	3963.60	25222.48							
3h	3963.22	25224.90							
4	3962.154	25231.68	$a\ ^4H_{4\frac{1}{2}} - x\ ^3H_{3\frac{1}{2}}$						
10c, V	3960.994	25239.07	$a\ ^4G_{3\frac{1}{2}} - y\ ^3I_{3\frac{1}{2}}$						
4	3960.636	25241.35	$a\ ^2H_{4\frac{1}{2}} - u\ ^4G_{3\frac{1}{2}}$						
4	3959.978	25245.55	$a\ ^4F_{3\frac{1}{2}} - y\ ^5D_{3\frac{1}{2}}$						
2	3959.54	25248.34	$b\ ^4F_{3\frac{1}{2}} - t\ ^4D_{3\frac{1}{2}}$						
15c, V	3959.356	25249.51	$b\ ^4F_{3\frac{1}{2}} - r\ ^2F_{3\frac{1}{2}}$	6		0	1.116	(1.120)	1.112
3	3959.144	25250.86							
7c	3958.129	25257.34	$a\ ^4H_{3\frac{1}{2}} - u\ ^4D_{3\frac{1}{2}}$						
1	3957.724	25259.93	$a\ ^2D_{2\frac{1}{2}} - s\ ^2D_{2\frac{1}{2}}$						
1	3957.25	25262.95	$b\ ^4F_{3\frac{1}{2}} - t\ ^4D_{1\frac{1}{2}}$						
7	3956.83	25265.63	$a\ ^4F_{4\frac{1}{2}} - y\ ^5D_{4\frac{1}{2}}$						
3c	3956.626	25266.94	$a\ ^4G_{4\frac{1}{2}} - z\ ^4H_{3\frac{1}{2}}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm⁻¹	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
3c	3956.40	25268.38	$a\ ^4G_{3½}-t\ ^4F_{3½}$						
20, V	3955.680	25272.98	$\begin{cases} a\ ^4F_{3½}-x\ ^3D_{3½} \\ b^4D_{3½}-s\ ^4G_{3½} \end{cases}$	6	0.330	1.152	1.40	(1.235)	1.565
1	3955.38	25274.89	$b\ ^2G_{3½}-r\ ^2G_{3½}$						
10	3953.071	25289.66	$a\ ^4H_{4½}-v\ ^3G_{3½}$	6	0.065	0.241	1.054	1.021	1.086?
4	3953.015	25290.02	$a\ ^4H_{4½}-u\ ^4D_{3½}$						
4	3950.966	25303.13	$b\ ^4F_{4½}-w\ ^2H_{3½}$						
9	3949.927	25309.79	$a\ ^4F_{3½}-z\ ^2G_{3½}$	4		0	1.002c	(1.029)	1.017
1	3949.81	25310.53	$b\ ^4P_{2½}-r\ ^4F_{3½}$						
8	3949.326	25313.64	$a\ ^2D_{1½}-p\ ^2D_{1½}$	7b, 6		0A	0.957	(0.953)	0.961
4A	3947.922	25322.64							
20, V	3947.516	25325.24	$a\ ^4G_{3½}-u\ ^4G_{3½}$	5	0.305	0.155	1.823	0.755	1.080
1	3946.98	25328.67	$a\ ^2H_{3½}-t\ ^4F_{3½}$						
2	3944.90	25342.04	$a\ ^2G_{3½}-p\ ^4D_{3½}$						
4A	3944.417	25345.14							
60, IV	3943.663	25349.99	$a\ ^4F_{3½}-y\ ^4D_{3½}$	4	0.266	0.131	0.626	1.025	1.291
4	3941.611	25363.18	$a\ ^2H_{3½}-x\ ^4H_{3½}$						
40c, V	3941.266	25365.41	$a\ ^6D_{3½}-y\ ^4F_{3½}$	5	0.503	0.251	2.850	1.592	1.089
2	3940.790	25368.48	$a\ ^2D_{1½}-y\ ^2S_{½}$						
3c	3939.26	25378.32	$b\ ^2G_{4½}-p\ ^4D_{3½}$						
20, V	3937.961	25386.60	$a\ ^4G_{3½}-u\ ^4G_{3½}$						
150, IV	3937.437	25390.07	$a\ ^6D_{4½}-y\ ^4F_{3½}$	6	0.213	0.965	1.440	1.546	1.333
10, V	3936.442	25396.47	$a\ ^4F_{3½}-x\ ^3D_{3½}$						
20c, V	3935.441	25402.95	$\begin{cases} a^4G_{3½}-t\ ^4F_{3½} \\ a^4G_{3½}-u\ ^4G_{3½} \end{cases}$						
2	3934.64	25408.12	$a\ ^2G_{3½}-w\ ^2G_{3½}$						
20, V	3934.405	25409.64	$a\ ^4F_{3½}-x\ ^4D_{3½}$	4	2.038	1.022	−0.614	0.405	2.443
12c, V	3934.142	25411.33	$\begin{cases} a^4H_{3½}-u\ ^4D_{3½} \\ b\ ^4F_{3½}-t\ ^4D_{3½} \end{cases}$						
8	3933.392	25416.18	$a\ ^4H_{4½}-y\ ^4H_{3½}$						
6	3933.013	25418.63	$a\ ^4P_{1½}-y\ ^2F_{2½}$?			0	1.00		
1	3932.59	25421.36	$a\ ^2H_{4½}-u\ ^4G_{3½}$						
3A	3931.933	25425.61							
8	3931.460	25428.67	$a\ ^2D_{1½}-x\ ^2P_{1½}$	6	0.632	0.958	1.265	0.949	1.581
1	3930.09	25437.53	$a\ ^2H_{4½}-t\ ^4F_{3½}$						
30c, IV	3929.296	25442.67	$a\ ^4F_{3½}-y\ ^4D_{3½}$	6	0.186	0.648	1.328	1.235	1.421
2	3928.265	25449.35	$a\ ^2F_{3½}-t\ ^4D_{3½}$						
9	3926.618	25460.03	$a\ ^4F_{3½}-276_{1½}$	4	0.132	0.067	0.94*	(1.235)	1.367
1	3926.203	25462.72	$b\ ^4P_{2½}-r\ ^4F_{3½}$						
2	3925.622	25466.49	$b\ ^4F_{3½}-w\ ^2H_{3½}$						
3	3925.53	25467.08	$a\ ^2F_{3½}-u\ ^2G_{3½}$						
4c	3925.18	25469.35	$a\ ^4H_{5½}-y\ ^4H_{3½}$						
40c, V	3924.995	25470.55	$a\ ^6D_{3½}-y\ ^4F_{3½}$	6	0.336	1.172	1.415	1.583	1.247
12c	3924.474	25473.93	$a\ ^4G_{4½}-t\ ^4F_{3½}$	6		0A	1.250	(1.23)	1.27
4	3923.80	25478.31							
12, V	3922.353	25487.71	$a\ ^4G_{3½}-x\ ^4H_{3½}$	6	0.374	1.317	0.896	1.082	0.708
4	3922.280	25488.18	$b\ ^4F_{3½}-t\ ^2D_{2½}$						
6	3921.671	25492.14	$a\ ^2G_{3½}-w\ ^2G_{3½}$	6		0	0.856	(0.885)	0.827
100c, IV	3920.198	25501.72	$a\ ^4G_{3½}-x\ ^4H_{4½}$	4		--	0.880	(1.26)	1.20
15c, V	3919.163	25508.45	$a\ ^4G_{4½}-x\ ^4H_{3½}$						
10, V	3919.005	25509.48	$a\ ^2G_{4½}-z\ ^2H_{3½}$						
4	3917.014	25522.45	$a\ ^2H_{4½}-x\ ^4H_{3½}$						
1d	3916.40	25526.45	$b\ ^4F_{3½}-r\ ^2F_{3½}$						
150, IV	3914.692	25537.59	$a\ ^4H_{3½}-y\ ^4H_{3½}$	6		0A	0.688	(0.690)	0.686
4	3914.362	25539.74	$b\ ^4F_{3½}-r\ ^2F_{3½}$						
8c	3913.15	25547.65	$a\ ^4D_{1½}-y\ ^2P_{1½}$						
15	3913.011	25548.56	$a\ ^2P_{1½}-s\ ^2F_{3½}$	4	0.332	(0.166)	0.344	1.175	0.843
4	3910.156	25567.21							
4	3909.665	25570.42	$\begin{cases} a\ ^4F_{1½}-z\ ^6D_{1½} \\ b\ ^4P_{1½}-q\ ^2F_{2½} \end{cases}$						
15	3909.600	25570.85	$a\ ^4G_{3½}-y\ ^2H_{4½}$						
3	3909.215	25573.37							
40, IV	3908.971	25574.96	$a\ ^4F_{1½}-y\ ^4D_{2½}$	4	0.759	0.372	0.000	0.380	1.139
8	3908.592	25577.44	$a\ ^2F_{3½}-u\ ^2G_{3½}$						

TABLE 4. *–First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
12, V	3906.900	25588.52	$a\ ^3G_{3½}-z\ ^4H_{3½}$	4		*w*	0.508	(0.883)	0.814
1*h*	3906.35	35592.12	$a\ ^3D_{2½}-u\ ^3D_{1½}$						
2	3904.83	25602.06							
30c, V	3904.188	25606.29	$a\ ^4G_{3½}-x\ ^4H_{3½}$	4		*w*	0.634	(0.742)	0.694
4*c*	3902.829	25615.21	$b\ ^4D_{2½}-w\ ^3P_{1½}$						
3	3901.88	25621.44	$b\ ^4D_{3½}-w\ ^3P_{1½}$						
5	3900.83	25628.34	$a\ ^4F_{4½}-y\ ^3G_{5½}$						
15*c*, V	3899.24	25638.79	$b\ ^4D_{2½}-s\ ^4G_{3½}$						
4	3898.94	25640.76	$a\ ^3H_{5½}-x\ ^4H_{3½}$						
20, V	3898.563	25643.24	$a\ ^4F_{3½}-z\ ^3F_{2½}$						
5	3898.01	25646.88							
2	3896.621	25656.02	$b\ ^4P_{2½}-s\ ^4G_{3½}$						
4	3896.00	25660.11							
20, V	3895.895	25660.80	$a\ ^3D_{1½}-u\ ^3F_{2½}$	4	0.094	0.047	0.727	0.962	0.868
1	3894.99	25666.76	$b\ ^4F_{4½}-t\ ^4D_{3½}$						
10	3894.70	25668.67	$a\ ^4D_{2½}-y\ ^4F_{3½}$						
1*d*	3894.33	25671.11	$b\ ^4D_{3½}-s\ ^4D_{3½}$						
50, IV	3894.039	25673.03	$a\ ^4H_{4½}-y\ ^4H_{3½}$	6		0*h*	0.977	(0.984)	0.970
40, IV	3893.733	25675.05	$a\ ^5D_{2½}-y\ ^6D_{1½}$	4	0.164	0.080	1.413	1.660	1.824
6	3893.325	25677.74	$a\ ^4G_{3½}-r\ ^3F_{2½}$						
4	3892.87	25680.74	$a\ ^3D_{1½}-x\ ^4S_{1½}$?						
4	3892.76	25681.46	$a\ ^4D_{3½}-u\ ^3F_{3½}$?						
5	3892.33	25684.30							
60, IV	3891.302	25691.09	$a\ ^6D_{3½}-y\ ^6D_{3½}$	4		*w*	1.519	(1.582)	1.632
6	3890.756	25694.69	$a\ ^4G_{3½}-t\ ^4F_{4½}$						
6	3889.800	25701.01	$a\ ^4F_{3½}-y\ ^3G_{3½}$						
8*c*	3889.64	25702.06							
1	3889.440	25703.39	$a\ ^3P_{0½}-u\ ^3D_{1½}$						
2	3888.68	25708.41	$b\ ^4F_{4½}-t\ ^4D_{3½}$						
1	3888.49	25709.67	$a\ ^4D_{2½}-s\ ^3D_{1½}$						
3	3888.29	25710.99							
6*h*	3886.664	25721.74							
20, V	3886.074	25725.65	$a\ ^5D_{1½}-y\ ^6D_{2½}$	4		0.718	1.184	(1.863)	3.220
100, IV	3885.686	25728.22	$a\ ^4H_{5½}-y\ ^4H_{5½}$	6		0*h*	1.13	(1.12)	1.15
150*c*, IV	3885.453	25729.76	$a\ ^4H_{6½}-y\ ^4H_{5½}$	6		0*h*	1.225	(1.22)	1.23
3	3884.519	25735.95							
80, V?	3883.141	25745.08	$a\ ^6D_{3½}-y\ ^4F_{3½}$	4	0.244	0.123	0.480	1.580	1.335
6	3882.894	25746.72							
8	3882.660	25748.27	$a\ ^3H_{6½}-y\ ^2I_{5½}$						
2	3880.543	25762.31							
7	3879.644	25768.29							
20, V	3878.965	25772.79	$a\ ^4F_{5½}-y\ ^4D_{4½}$						
40, V?	3878.817	25773.78	$a\ ^4D_{3½}-y\ ^4F_{4½}$	4	0.404	0.191	0.231	1.645	1.241
1	3878.082	25778.66	$a\ ^3D_{3½}-u\ ^4D_{4½}$						
60*c*, V	3877.557	25782.15	$a\ ^6D_{4½}-y\ ^6D_{3½}$	5	0.292	0.150	--	(1.549)	1.257
20*c*, V	3876.964	25786.10	$a\ ^4G_{4½}-x\ ^4H_{3½}$						
4	3876.810	25787.12							
20, V	3875.77	25794.04	$a\ ^4F_{3½}-y\ ^4D_{3½}$						
5	3875.697	25794.52	$a\ ^4H_{3½}-y\ ^4H_{3½}$ $a\ ^3P_{2½}-u\ ^4D_{2½}$						
10*d*	3875.421	25796.36	$a\ ^4G_{3½}-r\ ^3F_{3½}$						
1	3875.10	25798.50	$b\ ^4P_{1½}-400\ ^1_{2½}$						
5	3873.288	25810.57	$a\ ^3D_{3½}-s\ ^3G_{3½}$	4	0.291	--	0.198	1.216	0.925
5	3871.76	25820.75	$a\ ^4F_{5½}-x\ ^4D_{4½}$						
20*c*, V	3871.188	25824.57	$a\ ^4D_{3½}-z\ ^4P_{2½}$	4	0.232	0.114	1.026*w*	1.363	1.595
5	3870.665	25828.06	$a\ ^3G_{4½}-s\ ^4G_{3½}$						
1	3869.586	25835.26	$a\ ^4P_{2½}-x\ ^3G_{3½}$						
9*d*	3868.829	25840.32	$a\ ^4F_{3½}-x\ ^4D_{3½}$ $a\ ^4F_{4½}-x\ ^4D_{3½}$						
8	3868.570	25842.05	$a\ ^4P_{2½}-y\ ^4F_{3½}$ $a\ ^4D_{0½}-y\ ^2P_{1½}$						
50*c*, V?	3867.918	25846.40	$a\ ^5D_{4½}-z\ ^3G_{3½}$	5*us*	0.532	0.267	3.409	1.549	1.017
1	3867.393	25849.91	$a\ ^3G_{4½}-u\ ^3F_{3½}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
4	3866.24	25857.62	$b\ {}^4D_{3\frac{1}{2}}-411\ j_{4\frac{1}{2}}$						
10d	3865.041	25865.64	$a\ {}^2F_{3\frac{1}{2}}-u\ {}^2G_{4\frac{1}{2}}$						
1	3864.698	25867.94	$b\ {}^4P_{1\frac{1}{2}}-s\ {}^4G_{2\frac{1}{2}}$						
8	3864.364	25870.17	$a\ {}^2P_{1\frac{1}{2}}-u\ {}^4G_{2\frac{1}{2}}$						
1	3864.111	25871.87	$b\ {}^4F_{3\frac{1}{2}}-t\ {}^4D_{2\frac{1}{2}}$						
3c	3863.78	25874.08	$a\ {}^4G_{4\frac{1}{2}}-r\ {}^2F_{3\frac{1}{2}}$						
3c	3863.61	25875.22	$b\ {}^4F_{4\frac{1}{2}}-w\ {}^2H_{5\frac{1}{2}}$						
50, V?	3863.383	25876.74	$a\ {}^4P_{2\frac{1}{2}}-y\ {}^4S_{1\frac{1}{2}}$	6	0.239	0.358	1.839	1.720	1.959
20c, V	3862.926	25879.80	$a\ {}^6D_{4\frac{1}{2}}-y\ {}^6D_{3\frac{1}{2}}$						
2	3861.384	25890.14	$a\ {}^2P_{2\frac{1}{2}}-u\ {}^4D_{1\frac{1}{2}}$						
3c	3861.081	25892.17	$b\ {}^4F_{1\frac{1}{2}}-t\ {}^2D_{2\frac{1}{2}}$						
12c	3860.860	25893.65	$a\ {}^4G_{3\frac{1}{2}}-y\ {}^2I_{3\frac{1}{2}}$						
1	3860.694	25894.76	$b\ {}^4F_{1\frac{1}{2}}-x\ {}^2P_{1\frac{1}{2}}$						
4c	3859.237	25904.54							
40, V?	3858.953	25906.45	$a\ {}^6D_{1\frac{1}{2}}-y\ {}^4F_{1\frac{1}{2}}$	4	0.784	0.392	−0.099	1.861	1.077
1	3858.162	25911.76	$a\ {}^2F_{3\frac{1}{2}}-t\ {}^2G_{4\frac{1}{2}}$						
1	3858.00	25912.84	$a\ {}^6D_{1\frac{1}{2}}-y\ {}^6D_{1\frac{1}{2}}$						
6	3856.683	25921.70							
15	3855.456	25929.94	$a\ {}^6D_{3\frac{1}{2}}-y\ {}^4F_{2\frac{1}{2}}$	4		--	0.948	(3.323)	0.475
12	3855.146	25932.03	$a\ {}^4H_{4\frac{1}{2}}-y\ {}^4H_{5\frac{1}{2}}$						
9	3854.696	25935.04	$a\ {}^4H_{4\frac{1}{2}}-s\ {}^2F_{3\frac{1}{2}}$						
6	3854.127	25938.88	$a\ {}^6D_{4\frac{1}{2}}-x\ {}^4P_{3\frac{1}{2}}$						
4c	3853.89	25942.50	$\begin{cases} a\ {}^6D_{3\frac{1}{2}}-u\ {}^4D_{2\frac{1}{2}} \\ a\ {}^4P_{2\frac{1}{2}}-u\ {}^4F_{3\frac{1}{2}}? \end{cases}$						
20	3853.388	25943.86	$a\ {}^4H_{3\frac{1}{2}}-s\ {}^2F_{2\frac{1}{2}}$	4	0.156	0.078	0.299	0.689	0.845
4	3853.096	25945.83	$a\ {}^2H_{5\frac{1}{2}}-w\ {}^2H_{5\frac{1}{2}}$						
6c	3849.744	25968.41	$\begin{cases} a\ {}^2P_{1\frac{1}{2}}-t\ {}^4F_{1\frac{1}{2}} \\ a\ {}^4P_{2\frac{1}{2}}-w\ {}^2F_{3\frac{1}{2}} \end{cases}$						
1	3846.00	25993.69	$b\ {}^4D_{2\frac{1}{2}}-414\ j_{4\frac{1}{2}}$						
40, V	3845.900	25994.37	$a\ {}^6D_{2\frac{1}{2}}-y\ {}^6D_{2\frac{1}{2}}$	6		0.080	1.627	1.643	1.611
4c	3845.307	25998.38	$\begin{cases} a\ {}^4D_{1\frac{1}{2}}-x\ {}^4P_{2\frac{1}{2}} \\ b\ {}^4P_{1\frac{1}{2}}-r\ {}^4F_{2\frac{1}{2}} \end{cases}$						
2c	3845.079	25999.92	$\begin{cases} a\ {}^4D_{2\frac{1}{2}}-s\ {}^2D_{2\frac{1}{2}} \\ b\ {}^4F_{3\frac{1}{2}}-u\ {}^2G_{4\frac{1}{2}} \end{cases}$						
12	3844.090	26006.61	$a\ {}^4H_{4\frac{1}{2}}-y\ {}^4H_{5\frac{1}{2}}$						
10c	3843.927	26007.71	$a\ {}^4P_{2\frac{1}{2}}-v\ {}^4F_{2\frac{1}{2}}$	4	0.248	0.115	--	(1.596)	1.348
4	3843.615	26009.82	$a\ {}^4F_{2\frac{1}{2}}-y\ {}^4D_{1\frac{1}{2}}$						
4	3843.453	26010.92	$a\ {}^2H_{5\frac{1}{2}}-z\ {}^4H_{5\frac{1}{2}}$						
20, V	3842.709	26015.96	$a\ {}^2G_{3\frac{1}{2}}-y\ {}^2H_{3\frac{1}{2}}$	5		0h	1.200	(1.103)	1.133
30	3841.820	26021.97	$\begin{cases} a\ {}^2F_{3\frac{1}{2}}-t\ {}^2G_{3\frac{1}{2}} \\ b\ {}^4D_{1\frac{1}{2}}-414\ j_{4\frac{1}{2}} \end{cases}$	5		0h	1.004	(0.860)	0.924
2	3838.072	26047.39	$a\ {}^4D_{1\frac{1}{2}}-s\ {}^2D_{1\frac{1}{2}}$						
4	3837.995	26047.91	$a\ {}^4P_{2\frac{1}{2}}-w\ {}^4F_{3\frac{1}{2}}$						
12c	3837.077	26054.14	$b\ {}^4P_{2\frac{1}{2}}-s\ {}^4D_{2\frac{1}{2}}$	4	0.191	0.094	0.884	1.558	1.367
5c	3836.738	26056.44	$a\ {}^4H_{3\frac{1}{2}}-s\ {}^2F_{3\frac{1}{2}}$						
20, V	3836.452	26058.38	$a\ {}^2D_{1\frac{1}{2}}-v\ {}^2D_{2\frac{1}{2}}$	5	0.198	0.098	1.456	0.952	1.160
3c	3836.260	26059.69							
40, IV?	3835.176	26067.05	$a\ {}^6D_{2\frac{1}{2}}-y\ {}^6D_{1\frac{1}{2}}$	4	1.508	0.754	1.061	3.322	1.815
2	3834.575	26071.14	$b\ {}^4F_{2\frac{1}{2}}-w\ {}^4F_{2\frac{1}{2}}$						
6	3833.940	26075.46							
2	3833.769	26076.62	$a\ {}^4D_{2\frac{1}{2}}-x\ {}^4S_{1\frac{1}{2}}$						
10c	3833.257	26080.10	$a\ {}^2H_{5\frac{1}{2}}-y\ {}^2I_{6\frac{1}{2}}$	7b, 4?		0	1.11	(1.10)	1.10
1	3832.134	26087.75	$b\ {}^4D_{2\frac{1}{2}}-q\ {}^4F_{1\frac{1}{2}}$						
6d	3831.198	26094.12	$b\ {}^4D_{0\frac{1}{2}}-q\ {}^4F_{1\frac{1}{2}}$						
2	3831.074	26094.96	$a\ {}^4G_{3\frac{1}{2}}-r\ {}^2F_{3\frac{1}{2}}$						
1	3830.820	26096.69	$a\ {}^2D_{2\frac{1}{2}}-u\ {}^4D_{1\frac{1}{2}}$						
10	3830.006	26102.24	$a\ {}^4D_{1\frac{1}{2}}-y\ {}^2S_{0\frac{1}{2}}$	4	0.880	0.440	0.761	1.201	2.061
4	3829.659	26104.61	$\begin{cases} b\ {}^3G_{4\frac{1}{2}}-p\ {}^4F_{3\frac{1}{2}} \\ b\ {}^4D_{2\frac{1}{2}}-s\ {}^2G_{3\frac{1}{2}} \end{cases}$						
4	3828.045	26115.61	$b\ {}^4D_{1\frac{1}{2}}-q\ {}^4F_{1\frac{1}{2}}$						
6	3827.090	26122.13	$a\ {}^4P_{2\frac{1}{2}}-w\ {}^2F_{2\frac{1}{2}}$						
12	3827.015	26122.64	$a\ {}^2F_{3\frac{1}{2}}-t\ {}^2G_{3\frac{1}{2}}$	4	0.104	w	0.648	(1.130)	1.044
3	3826.574	26125.65	$a\ {}^2F_{2\frac{1}{2}}-t\ {}^4G_{3\frac{1}{2}}$						
5	3825.410	26133.60	$a\ {}^2D_{2\frac{1}{2}}-w\ {}^4S_{1\frac{1}{2}}$						
100, IV	3824.882	26137.21	$a\ {}^6D_{3\frac{1}{2}}-y\ {}^6D_{2\frac{1}{2}}$	6	0.333	1.171	1.415	1.581	1.248
3	3823.256	26148.33	$b\ {}^4D_{2\frac{1}{2}}-416\ j_{3\frac{1}{2}}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_1
1	2	3	4	5	6	7	7	8	10
6	3823.135	26149.15	$a\ ^5H_{11/2}-y\ ^5I_{9/2}$						
4	3822.956	26150.38							
12c	3821.201	26162.38	$a\ ^4D_{1/2}-x\ ^4P_{3/2}$	6	0.390	0.585	1.393	1.198	1.588
40, V	3819.148	26176.45	$a\ ^4F_{9/2}-y\ ^4S_{3/2}$	4	0.692	--	1.604	2.642	1.950
6c	3818.190	26183.01	$b\ ^4F_{3/2}-w\ ^3P_{1/2}$						
3c	3816.645	26193.62							
15	3816.342	26195.69	$a\ ^4F_{3/2}-y\ ^4P_{3/2}$	4	0.624	0.314	0.090	1.026	1.650
60c, IV?	3815.507	26201.43	$a\ ^2D_{3/2}-z\ ^2G_{5/2}$	6	0.567	1.989	1.296	1.580	1.013
4	3814.188	26210.49	$a\ ^4F_{3/2}-z\ ^2F_{5/2}$						
5	3813.470	26215.42							
5c	3813.01	26218.59	$a\ ^2P_{1/2}-t\ ^4D_{1/2}$						
50, III?	3811.035	26232.17	$a\ ^4D_{1/2}-y\ ^6D_{3/2}$	4	0.242	0.125	1.248	1.852	1.610
3c	3810.88	26233.24	$a\ ^4D_{5/2}-x\ ^4P_{3/2}$						
80c, V	3810.50	26235.85	$a\ ^4H_{15/2}-u\ ^4G_{9/2}$	4?		w	1.18	(1.22)	1.23
2c	3807.95	26253.43	$a\ ^4P_{1/2}-w\ ^4F_{1/2}$						
1	3807.485	26256.63	$a\ ^4G_{3/2}-t\ ^4D_{1/2}$						
10	3806.631	26262.52	$b\ ^4P_{1/2}-s\ ^4D_{1/2}$	4	0.376	0.19?	0.725	1.665	1.289
30, V	3806.196	26265.52	$a\ ^4H_{13/2}-u\ ^4G_{9/2}$	4	0.147	0.074	0.324	0.691	0.838
40, Cb II	3804.733	26275.62	$a\ ^4H_{15/2}-u\ ^4G_{9/2}$	4		w	1.01	(1.12)	1.17
10c	3804.204	26279.27	$b\ ^4D_{3/2}-q\ ^4F_{3/2}$						
100, IV?	3803.879	26281.52	$a\ ^6D_{3/2}-z\ ^2G_{7/2}$	6	0.477	2.135	1.313	1.551	1.074
1	3803.65	26283.10	$a\ ^4P_{3/2}-w\ ^4D_{1/2}$						
400r, IV?	3802.928	26288.09	$a\ ^6D_{3/2}-z\ ^6D_{3/2}$	4		w	1.514	(1.582)	1.636
6	3802.636	26290.11	$b\ ^4F_{3/2}-u\ ^2G_{9/2}$						
5	3802.555	26290.67							
4	3802.480	26291.19	$a\ ^4F_{3/2}-y\ ^4P_{3/2}$						
20, V	3801.302	26299.34	$a\ ^4H_{13/2}-u\ ^4G_{9/2}$						
20, V	3800.941	26301.84	$a\ ^2G_{9/2}-v\ ^4G_{9/2}$						
5	3800.197	26306.98	$b\ ^4D_{1/2}-q\ ^4F_{3/2}$						
5	3799.486	26311.91	$a\ ^4G_{9/2}-w\ ^2H_{9/2}$						
300r, III	3798.127	26321.32	$a\ ^6D_{1/2}-x\ ^6D_{1/2}$						
15c	3796.850	26330.17	$a\ ^2F_{5/2}-v\ ^2H_{9/2}$						
12	3796.599	26331.92	$a\ ^4F_{3/2}-z\ ^2F_{5/2}$						
20c, V	3796.440	26333.02	$b\ ^4D_{3/2}-416\ 1_{3/2}$						
30h, V	3795.543	26339.24							
2	3795.182	26341.75	$a\ ^4D_{5/2}-v\ ^2D_{5/2}$						
15	3794.476	26346.65	$a\ ^2H_{11/2}-w\ ^2H_{9/2}$	6		0.049	0.929	0.923	0.936
5c	3793.727	26351.85	$a\ ^2G_{9/2}-u\ ^2F_{5/2}$						
7c	3791.999	26363.86	$a\ ^4H_{15/2}-t\ ^4F_{5/2}$						
8	3791.446	26367.70	$a\ ^4P_{3/2}-w\ ^4F_{1/2}$						
100r, III	3791.209	26369.35	$a\ ^6D_{3/2}-y\ ^6D_{3/2}$	6	0.120	0.552	1.483	1.543	1.422
200r, III	3790.138	26376.80	$a\ ^6D_{3/2}-x\ ^6D_{3/2}$	4		0h	1.517	(1.549)	1.567
20	3789.502	26381.23	$a\ ^4F_{3/2}-z\ ^2F_{5/2}$						
3c	3788.69	26386.88				0	0.682		
4	3788.188	26390.38	$a\ ^2D_{3/2}-u\ ^2D_{3/2}$						
15	3787.480	26395.31	$a\ ^4F_{3/2}-x\ ^4D_{3/2}$						
8c	3787.280	26396.70	$a\ ^4D_{3/2}-y\ ^2S_{1/2}$						
150, IV?	3787.064	26398.21	$a\ ^6D_{3/2}-x\ ^6D_{3/2}$	4	0.577	0.288	1.572	1.860	2.437
10, V	3786.227	26404.05	$a\ ^4F_{3/2}-x\ ^4D_{3/2}$						
6c	3786.10	26404.93							
3	3785.384	26409.92	$a\ ^4P_{1/2}-p\ ^4F_{1/2}$						
1	3784.73	26414.49	$a\ ^4D_{1/2}-x\ ^2S_{1/2}$						
20c	3783.844	26420.67	$a\ ^4H_{15/2}-u\ ^4G_{9/2}$	6	0.367	1.285	0.872	1.055	0.688
1	3782.71	26428.59	$a\ ^4G_{9/2}-z\ ^2P_{1/2}$						
5c	3782.40	26430.76	$a\ ^4D_{3/2}-u\ ^2D_{3/2}$						
80, III	3781.017	26440.43	$a\ ^6D_{3/2}-y\ ^6D_{3/2}$	4as	0.403	0.201	0.235	1.647	1.243
4	3779.22	26453.00							
1	3779.03	26454.33	$a\ ^4D_{1/2}-y\ ^2D_{3/2}$						
5	3778.675	26456.82	$a\ ^4D_{5/2}-x\ ^4P_{5/2}$						
15c	3777.670	26463.85	$b\ ^4D_{3/2}-q\ ^4F_{3/2}$						
8	3777.277	26466.61	$a\ ^4F_{5/2}-z\ ^4H_{7/2}$						
7	3776.605	26471.32	$a\ ^4F_{3/2}-270_{3/2}$						
6c	3776.157	26474.46	$b\ ^4F_{3/2}-s\ ^4F_{3/2}$						
20, V	3775.449	26479.42	$a\ ^4H_{15/2}-u\ ^4G_{9/2}$	6	0.204	0.914	1.088	0.986	1.190
2	3775.16	26481.45	$a\ ^2D_{3/2}-u\ ^4D_{3/2}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ_{air} A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	7	8	10
8	3774.44	26486.50	a $^4P_{2½}$—u $^4F_{1½}$†			0.734	0.404		
4	3774.39	26486.85							
6	3773.628	26492.20	a $^4F_{2½}$—z $^4D_{1½}$ b $^4F_{4½}$—t $^2G_{4½}$						
10	3773.154	26495.53	a $^4H_{4½}$—t $^4F_{3½}$	4	0.183	0.095	0.336	0.975	1.158
3	3772.721	26498.57	a $^4F_{3½}$—y $^6P_{3½}$						
40, V	3771.848	26504.70	a $^6D_{2½}$—z $^2G_{3½}$	4	0.637	0.321	−0.569	1.645	1.009
3	3771.78	26505.18							
2	3771.14	26509.68	a $^4P_{1½}$—r $^4F_{1½}$						
20, V	3770.870	26511.58							
12c	3770.71	26512.70	a $^4H_{4½}$—u $^4G_{4½}$						
4	3770.332	26515.36							
15	3769.983	26517.81	a $^2H_{5½}$—w $^2H_{5½}$	6		0.040	1.088	1.092	1.083
4	3769.624	26520.34	b $^4D_{3½}$—p $^2F_{3½}$						
20, V	3769.145	26523.71	a $^4F_{3½}$—x $^4D_{3½}$	5	0.178	0.068	0.491	0.402	0.222
5	3767.421	26535.85	a $^4P_{2½}$—w $^4G_{3½}$						
30c, V	3766.140	26544.87	a $^6D_{3½}$—y $^4D_{1½}$	5	0.356	0.179	2.181	1.647	1.290
6	3765.794	26547.31	a $^2P_{1½}$—t $^2D_{1½}$						
40c, V	3765.074	26552.39	a $^6D_{3½}$—x $^6D_{3½}$	6	0.870	0.435	2.878	3.313	2.443
4	3764.536	26556.18	b $^4F_{3½}$—s $^4F_{3½}$						
25, V	3764.115	26559.15	a $^6D_{1½}$—x $^6D_{1½}$						
4	3763.730	26561.87	b $^4P_{2½}$—414$I_{½}$						
40, III	3763.492	26563.55	a $^6D_{1½}$—y $^4D_{½}$	5	0.718	0.360	2.220	1.861	1.143
10h	3762.445	26570.94							
10	3761.16	26580.02	a $^4P_{1½}$—w $^4D_{½}$						
15	3761.11	26580.37	a $^4H_{4½}$—x $^4H_{3½}$						
12	3760.646	26583.65	a $^4H_{3½}$—t $^4F_{1½}$						
200r, III	3759.556	26591.36	a $^6D_{3½}$—x $^6D_{2½}$	6		0.000	1.630	(1.652)	1.611
2	3757.62	26605.06	a $^2F_{2½}$—400$I_{5½}$						
4c	3757.02	26609.31							
7	3756.251	26614.75	b $^4F_{1½}$—s $^4F_{1½}$						
4c	3755.940	26616.96	a $^4H_{3½}$—t $^4F_{1½}$						
20, V	3755.764	26618.20	a $^4H_{3½}$—x $^4H_{2½}$	5	0.138	0.070	1.738	1.117	0.979
6c	3755.636	26619.11	a $^4H_{4½}$—x $^4H_{3½}$						
10	3755.280	26621.57	a $^4F_{2½}$—z $^4S_{1½}$						
1d	3754.86	26624.61	a $^4G_{4½}$—u $^2G_{3½}$						
3	3754.228	26629.09	a $^2D_{2½}$—s $^2F_{2½}$						
1	3753.47	26634.47	b $^2G_{3½}$—n $^2F_{2½}$						
40, IV	3753.171	26636.59	a $^6D_{3½}$—z $^2G_{3½}$	4	0.807	0.255	−0.691	1.502	1.085
9	3752.723	26639.77	a $^4F_{1½}$—y $^6P_{1½}$						
5	3752.297	26642.80							
10	3750.637	26654.59	a $^4F_{1½}$—z $^2F_{2½}$						
5	3750.517	26655.44	b $^4P_{2½}$—q $^4F_{1½}$?						
6	3750.223	26657.53	a $^4P_{2½}$—x $^2D_{1½}$						
1	3749.415	26663.28	a $^4G_{3½}$—w $^2H_{2½}$						
1	3749.248	26664.46	a $^6D_{2½}$—y $^4D_{2½}$						
20, V	3748.557	26669.38	a $^2G_{3½}$—y $^2H_{2½}$	5		0h	1.194	(0.885)	0.954
1	3748.41	26670.42	a $^2G_{2½}$—r $^2D_{2½}$						
3	3747.841	26674.47	a $^2F_{2½}$—s $^4G_{2½}$						
25, V	3746.904	26681.14				w	1.08		
6	3745.476	26691.32	a $^4F_{2½}$—y $^6P_{1½}$						
4	3744.279	26699.85	b $^4F_{4½}$—v $^2H_{5½}$						
40c, IV	3744.007	26701.79	a $^6H_{3½}$—x $^6H_{2½}$	6		0	0.695	(0.690)	0.700
200r, III	3742.393	26713.31	a $^6D_{2½}$—x $^6D_{1½}$						
3	3742.09	26715.47	a $^4P_{1½}$—w $^4F_{2½}$						
2	3741.99	26716.18	b $^4P_{2½}$—416$I_{5½}$						
30c, IV	3741.776	26717.71	a $^6D_{2½}$—y $^4D_{2½}$						
1	3741.553	26719.30	a $^2G_{4½}$—p $^2G_{3½}$						
40, III	3740.845	26724.36	a $^6D_{1½}$—y $^6D_{½}$						
8c	3740.537	26726.56	a $^4H_{5½}$—y $^2I_{5½}$						
300r, III	3739.80	26731.83	a $^6D_{3½}$—x $^6D_{½}$	7b, 6		0h	1.573	(1.582)	1.564
4	3738.51	26741.05	a $^2D_{1½}$—u $^4D_{½}$						
30, V	3738.427	26741.64	a $^6D_{2½}$—s $^6F_{2½}$	4		w	0.948	(1.206)	1.132
4h	3736.32	26756.72							
6	3734.733	26768.09	a $^4F_{1½}$—w $^4D_{½}$						
15	3733.622	26776.06	a $^4F_{1½}$—z $^6P_{1½}$	6	1.045	1.578	0.924	0.401	1.446

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm⁻¹	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
15d	3733.344	26778.05	$183_{3/4} - u\ ^2H^1_{1/2}$			w	1.25h		
5c	3732.702	26782.66	$a\ ^6D_{1/2} - y\ ^6D^1_{1/2}$						
15	3732.034	26787.45	$a\ ^4H_{3/2} - t\ ^4F^1_{1/2}$	6	0.267	1.195	1.116	0.983	1.249
8c	3731.534	26791.04							
1	3731.377	26792.17	$a\ ^6D_{1/2} - v\ ^2D^1_{1/2}$						
7d	3729.613	26804.84	$a\ ^6D_{3/2} - y\ ^2G^1_{1/2}$; $a\ ^2F^1_{5/2} - r\ ^4F^1_{3/2}$						
20	3727.229	26821.98	$a\ ^4H_{3/2} - x\ ^4H^1_{1/2}$	6		w	1.005	(0.984)	1.026
250, III	3726.235	26829.14	$a\ ^6D_{1/2} - x\ ^6D^1_{1/2}$	4	0.238	0.120	1.201	1.857	1.618
4c	3725.648	26833.36	$a\ ^4G_{3/2} - v\ ^2H^1_{1/2}$						
20, V	3725.195	26836.63	$a\ ^6D_{3/2} - u\ ^6D^1_{1/2}$						
4	3724.96	26838.32	$b\ ^4F_{3/2} - t\ ^4G^1_{1/2}$						
4	3724.47	26841.85	$a\ ^4P_{1/2} - u\ ^4F^1_{1/2}$						
3h	3723.742	26847.10	$b\ ^4P_{3/2} - q\ ^4F^1_{3/2}$						
6	3723.10	26851.73							
20c	3722.942	26852.87							
15	3722.328	26857.30	$b\ ^4F_{3/2} - v\ ^2H^1_{1/2}$						
4	3722.170	26858.44	$a\ ^4F_{3/2} - y\ ^4F^1_{3/2}$						
4	3721.637	26862.28	$a\ ^2P_{1/2} - t\ ^2D^1_{3/2}$						
10	3721.517	26863.15	$b\ ^4F_{3/2} - v\ ^2H^1_{1/2}$						
6	3721.277	26864.88	$a\ ^2P_{1/2} - x\ ^2P^1_{3/2}$						
1h	3719.52	26877.57	$b\ ^4D_{1/2} - s\ ^2D^1_{3/2}$						
6	3718.524	26884.77	$a\ ^4G_{3/2} - s\ ^4F^1_{3/2}$						
30, V	3717.538	26891.90	$a\ ^4H_{3/2} - r\ ^2F^1_{5/2}$	4	0.185			(0.690)	0.875
40c, V	3717.01	26895.72	$a\ ^4H_{3/2} - x\ ^4H^1_{1/2}$						
30c, V	3716.214	26901.48	$a\ ^6D_{3/2} - y\ ^6D^1_{1/2}$						
6	3715.974	26903.22	$b\ ^4F_{3/2} - t\ ^4G^1_{1/2}$						
4c	3715.196	26908.86	$a\ ^4H_{1/2} - t\ ^4F^1_{1/2}$						
5c	3714.852	26911.35	$b\ ^4D_{3/2} - r\ ^2G^1_{1/2}$						
20, V	3713.819	26918.83	$a\ ^6D_{3/2} - 276\ ^1/_2$; $a\ ^2H_{1/2} - w\ ^2H^1_{1/2}$	5	0.216	--	2.108	(1.582)	1.366
300r, III	3713.018	26924.64	$a\ ^6D_{3/2} - x\ ^6D^1_{1/2}$	7b, 6		w	1.548	(1.549)	1.548
6	3712.554	26928.00	$b\ ^4F_{3/2} - s\ ^4F^1_{3/2}$						
12	3711.782	26933.61	$a\ ^4P_{3/2} - v\ ^2F^1_{5/2}$						
60, V	3711.343	26936.79	$a\ ^6D_{3/2} - y\ ^6D^1_{1/2}$	4	2.024	1.012	0.282	3.318	1.294
20c	3710.448	26943.29	$a\ ^4H_{1/2} - x\ ^4H^1_{1/2}$	5	0.309	0.152	--	(0.690)	0.999
2	3709.947	26946.92	$a\ ^2G_{1/2} - x\ ^2H^1_{1/2}$						
3	3709.802	26947.98							
6	3709.736	26948.46	$a\ ^4F_{3/2} - z\ ^2F^1_{5/2}$						
25, V	3709.422	26950.74	$a\ ^4P_{1/2} - w\ ^4D^1_{1/2}$; $a\ ^2D_{3/2} - u\ ^2G^1_{1/2}$	6	0.526	0.795	1.451	1.714	1.188
6	3708.900	26954.53	$a\ ^2F_{7/2} - q\ ^2F^1_{5/2}$						
4c	3708.38	26958.31							
10	3707.803	26962.51	$a\ ^4F_{3/2} - x\ ^4D^1_{1/2}$						
7c	3707.088	26967.70	$a\ ^6D_{3/2} - y\ ^6D^1_{3/2}$						
10c	3705.602	26978.52							
3	3704.628	26985.61	$a\ ^2P_{1/2} - t\ ^4F^1_{1/2}$						
40c, V	3704.137	26989.19	$a\ ^4H_{3/2} - x\ ^4H^1_{3/2}$	7b, 6		w	1.21	(1.22)	1.22
20c, V	3703.916	26990.80	$a\ ^4G_{3/2} - s\ ^2H^1_{1/2}$	6	0.117			(1.27)	1.15
30c, V	3703.167	26996.26	$a\ ^4G_{3/2} - s\ ^4F^1_{3/2}$			0.278	1.434		
4	3701.99	27004.84	$a\ ^2G_{3/2} - z\ ^2G^1_{1/2}$; $a\ ^4D_{3/2} - s\ ^2G^1_{1/2}$						
30c	3699.928	27019.89				0	0.88		
5	3699.582	27022.42							
5	3699.078	27026.10	$b\ ^4F_{3/2} - s\ ^4F^1_{3/2}$						
3	3698.893	27027.45	$b\ ^4F_{3/2} - 4003^1/_2$						
200, III	3697.850	27035.08	$a\ ^6D_{3/2} - z\ ^6D^1_{3/2}$	4	0.088	0.044	1.354	1.662	1.574
20, V	3697.397	27038.39	$a\ ^4P_{3/2} - w\ ^4D^1_{3/2}$	4	0.262	0.132	0.697	(1.596)	1.334
1	3697.155	27040.16	$a\ ^2F_{5/2} - s\ ^4G^1_{5/2}$						
6d	3697.024	27041.12	$a\ ^4F_{3/2} - z\ ^4H^1_{1/2}$						
20, V	3694.669	27058.35	$a\ ^4H_{3/2} - y\ ^2H^1_{1/2}$	6us	0.13			(1.22)	1.09
5	3693.767	27064.96	$a\ ^2F_{5/2} - q\ ^2F^1_{5/2}$						
4	3693.667	27065.69	$a\ ^4F_{3/2} - z\ ^6S^1_{5/2}$						
20, V	3693.365	27067.91	$a\ ^4P_{5/2} - w\ ^6D^1_{5/2}$	6	2.606	1.303	1.347	2.650	0.044

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ_{air} A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	ϕ_1	ϕ_2
1	2	3	4	5	6	7	8	9	10
1h	3692.518	27074.11	$b\ ^3G_{4\frac{1}{2}}-u\ ^3H_{3\frac{1}{2}}$						
3	3691.37	27082.53							
5	3689.409	27096.93	$b\ ^4F_{3\frac{1}{2}}-s\ ^4G_{3\frac{1}{2}}$						
15	3689.038	27099.65	$a\ ^4H_{4\frac{1}{2}}-z\ ^4H_{3\frac{1}{2}}$						
4	3688.81	27101.33	$a\ ^3G_{3\frac{1}{2}}-u\ ^3D_{2\frac{1}{2}}$						
15	3688.608	27102.15	$\begin{cases} a\ ^6D_{3\frac{1}{2}}-z\ ^7F_{3\frac{1}{2}} \\ a\ ^6S_{2\frac{1}{2}}-z\ ^7P_{2\frac{1}{2}} \end{cases}$						
8	3687.440	27111.40	$a\ ^4G_{3\frac{1}{2}}-s\ ^4F_{3\frac{1}{2}}$						
3	3686.655	27117.09							
10	3686.557	27117.89	$a\ ^4F_{3\frac{1}{2}}-z\ ^4H_{3\frac{1}{2}}$						
3	3686.068	27121.49	$a\ ^4P_{2\frac{1}{2}}-w\ ^3D_{1\frac{1}{2}}$						
10c	3685.128	27128.40	$a\ ^3P_{1\frac{1}{2}}-z\ ^3P_{1\frac{1}{2}}^0$						
5	3684.253	27134.85	$\begin{cases} a\ ^3H_{3\frac{1}{2}}-t\ ^3G_{3\frac{1}{2}} \\ b\ ^3G_{4\frac{1}{2}}-o\ ^3D_{3\frac{1}{2}} \end{cases}$						
1	3684.18	27135.39	$a\ ^4F_{1\frac{1}{2}}-y\ ^6P_{1\frac{1}{2}}$						
5c	3683.973	27136.91	$a\ ^4D_{2\frac{1}{2}}-u\ ^4D_{2\frac{1}{2}}$						
1	3682.13	27150.49	$a\ ^3F_{2\frac{1}{2}}-s\ ^4G_{2\frac{1}{2}}$						
3	3681.360	27156.17							
5	3680.857	27159.88	$a\ ^4D_{3\frac{1}{2}}-y\ ^3G_{3\frac{1}{2}}$						
10c	3678.70	27175.81	$b\ ^4D_{3\frac{1}{2}}-q\ ^4D_{2\frac{1}{2}}$						
4	3677.905	27181.68							
15	3677.771	27182.67	$a\ ^3G_{4\frac{1}{2}}-t\ ^3F_{3\frac{1}{2}}$						
20	3677.084	27187.75	$a\ ^4H_{4\frac{1}{2}}-r\ ^3F_{3\frac{1}{2}}$	4	0.125	0.065	--	(0.984)	1.109
20	3676.307	27193.50	$b\ ^4F_{3\frac{1}{2}}-t\ ^4G_{3\frac{1}{2}}$	5	0.252	0.377	--	(0.852)	1.106
10	3675.304	27200.92	$a\ ^4H_{3\frac{1}{2}}-w\ ^3H_{3\frac{1}{2}}$						
5	3675.17	27201.91							
40c, V	3674.787	27204.74	$a\ ^4D_{2\frac{1}{2}}-y\ ^4D_{1\frac{1}{2}}$	4	0.232	0.116	0.841	1.655	1.423
15	3674.601	27205.45	$\begin{cases} a\ ^4D_{1\frac{1}{2}}-y\ ^4D_{1\frac{1}{2}} \\ a\ ^4F_{3\frac{1}{2}}-y\ ^4G_{3\frac{1}{2}} \end{cases}$						
4	3674.469	27207.10	$a\ ^4H_{4\frac{1}{2}}-y\ ^3H_{4\frac{1}{2}}$						
8c	3673.227	27216.30	$b\ ^4F_{4\frac{1}{2}}-r\ ^4F_{3\frac{1}{2}}$						
4	3672.726	27220.01	$a\ ^3F_{3\frac{1}{2}}-q\ ^3F_{3\frac{1}{2}}$						
8	3672.580	27221.09	$a\ ^3G_{3\frac{1}{2}}-o\ ^3G_{3\frac{1}{2}}$	6		0.065	0.914	0.903	0.925
9	3672.443	27222.11	$a\ ^6D_{3\frac{1}{2}}-27683_{3\frac{1}{2}}$						
6	3671.735	27227.36	$b\ ^4F_{3\frac{1}{2}}-r\ ^4F_{3\frac{1}{2}}$						
12	3671.372	27230.05	$a\ ^4G_{3\frac{1}{2}}-s\ ^4F_{3\frac{1}{2}}$	6	0.251	0.602	0.856	0.722	0.973
20d	3669.736	27242.19	$b\ ^4F_{1\frac{1}{2}}-t\ ^4G_{2\frac{1}{2}}$	5	0.218	0.109	0.943	0.398	0.616
8h	3669.347	27245.08							
40, V	3669.009	27247.58	$a\ ^4P_{1\frac{1}{2}}-w\ ^4D_{1\frac{1}{2}}$	4	0.402	0.196	0.712	1.718	1.316
20, V	3668.626	27250.43	$a\ ^4P_{2\frac{1}{2}}-w\ ^4D_{1\frac{1}{2}}$	5	1.444	0.722	0.457	2.623	1.179
3	3668.435	27251.85	$b\ ^4D_{2\frac{1}{2}}-r\ ^4D_{1\frac{1}{2}}^0$						
8	3667.760	27256.86							
10c	3667.665	27257.57	$a\ ^4H_{3\frac{1}{2}}-t\ ^2D_{2\frac{1}{2}}$						
12c	3667.001	27262.50	$a\ ^4G_{4\frac{1}{2}}-s\ ^4F_{3\frac{1}{2}}$						
15	3666.534	27265.98	$a\ ^4H_{4\frac{1}{2}}-z\ ^4H_{4\frac{1}{2}}$						
10d	3665.157	27276.22	$b\ ^4F_{4\frac{1}{2}}-t\ ^4G_{3\frac{1}{2}}$	7b, 6		0	1.229	(1.224)	1.234
7	3664.822	27278.72	$a\ ^2H_{4\frac{1}{2}}-u\ ^2G_{3\frac{1}{2}}$						
80, III	3664.692	27279.68	$a\ ^6D_{3\frac{1}{2}}-z\ ^6D_{3\frac{1}{2}}$	4		w	1.437	(1.582)	1.528
6	3663.432	27289.07	$b\ ^4F_{2\frac{1}{2}}-r\ ^4F_{1\frac{1}{2}}$						
2	3663.313	27289.95	$a\ ^4G_{3\frac{1}{2}}-t\ ^3G_{3\frac{1}{2}}$						
8c	3663.167	27291.04	$a\ ^4D_{2\frac{1}{2}}-u\ ^4D_{1\frac{1}{2}}$						
5	3662.927	27292.83							
15	3662.051	27299.36	$a\ ^4F_{1\frac{1}{2}}-z\ ^2P_{1\frac{1}{2}}$	4	0.366	0.181	0.223	0.406	0.772
10c	3661.680	27302.12	$a\ ^3D_{3\frac{1}{2}}-t\ ^3F_{3\frac{1}{2}}$						
2	3660.74	27309.13	$a\ ^4H_{3\frac{1}{2}}-r\ ^3F_{3\frac{1}{2}}$						
2	3660.498	27310.94	$a\ ^4D_{1\frac{1}{2}}-u\ ^4D_{1\frac{1}{2}}$						
100, IV	3660.364	27311.94	$a\ ^4F_{4\frac{1}{2}}-y\ ^4G_{3\frac{1}{2}}$	6	0.097	0.436	1.325	1.373	1.276
7d	3658.750	27323.98	$b\ ^4F_{4\frac{1}{2}}-q\ ^3F_{3\frac{1}{2}}$						
4	3658.648	27324.74	$a\ ^3H_{4\frac{1}{2}}-t\ ^3G_{3\frac{1}{2}}$						
4	3658.604	27325.07	$a\ ^4P_{1\frac{1}{2}}-z\ ^2D_{1\frac{1}{2}}$						
8	3657.897	27330.36	$a\ ^3F_{3\frac{1}{2}}-q\ ^3F_{3\frac{1}{2}}$	6		0.15	0.69*	(0.86)	0.92
4	3657.693	27331.88	$b\ ^4F_{1\frac{1}{2}}-s\ ^4F_{2\frac{1}{2}}$						
4	3657.254	27335.16	$a\ ^4H_{3\frac{1}{2}}-y\ ^3H_{4\frac{1}{2}}$						

TABLE 4.—*First spectrum of columbium* (Cb 1)—Continued

Intensity Arc	λ_{air} A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
15	3657.110	27336.24	$b\ {}^4F_{3½}-t\ {}^4G_{5½}$	4		0	1.02	(1.22)	1.16
5h	3656.495	27340.83	$b\ {}^4D_{3½}-p\ {}^4D_{3½}$						
1	3656.265	27342.55	$a\ {}^2H_{5½}-s\ {}^2H_{5½}$						
20	3655.975	27344.72	$a\ {}^6D_{1½}-y\ {}^6P_{2½}$	4	0.606	0.303	1.563	1.806	2.472
10c	3654.430	27356.28	$a\ {}^4F_{4½}-x\ {}^4F_{5½}$						
4	3653.616	27362.38	$b\ {}^4D_{1½}-p\ {}^4D_{2½}$						
4	3653.276	27364.92	$a\ {}^4F_{3½}-z\ {}^4H_{4½}$ $a\ {}^6S_{2½}-w\ {}^4P_{1½}$						
6	3651.304	27379.70	$b\ {}^4F_{3½}-r\ {}^4F_{4½}$						
40, V	3650.803	27383.46	$a\ {}^6D_{4½}-y\ {}^3G_{4½}$						
5	3650.516	27385.61							
2	3650.31	27387.16	$b\ {}^4F_{2½}-s\ {}^4G_{3½}$						
4	3650.168	27388.22	$a\ {}^2G_{4½}-y\ {}^4H_{5½}$						
60, III	3649.854	27390.58	$a\ {}^6D_{2½}-y\ {}^4P_{1½}$	7b, 5		0	1.654	(1.652)	1.649
2d	3648.063	27404.03	$b\ {}^4P_{1½}-416\frac{1}{2}_{5½}$						
7	3647.867	27405.50	$a\ {}^6D_{3½}-z\ {}^3F_{3½}$						
7	3647.724	27406.57	$a\ {}^4F_{1½}-x\ {}^4D_{2½}$						
10c	3647.306	27409.71	$a\ {}^4G_{3½}-t\ {}^4G_{4½}$ $b\ {}^4F_{4½}-s\ {}^4G_{5½}$	5		0	1.319	1.255	(1.227)
4	3646.118	27418.65	$a\ {}^6S_{2½}-w\ {}^4P_{2½}$ $a\ {}^4D_{0½}-u\ {}^2D_{1½}$						
9	3645.360	27424.35	$a\ {}^4P_{2½}-w\ {}^2D_{2½}$						
20, V	3644.935	27427.54	$a\ {}^2D_{1½}-s\ {}^2F_{2½}$	4	0.112	0.054	0.682	0.963	0.851
1h	3644.17	27433.30	$b\ {}^4D_{2½}-p\ {}^4F_{3½}$						
20c	3643.725	27436.65	$b\ {}^4D_{3½}-r\ {}^4D_{4½}$	6		0	1.409	(1.43)	1.39
5	3643.526	27438.15	$a\ {}^2F_{3½}-s\ {}^2D_{4½}$						
15	3643.343	27439.53	$b\ {}^4F_{3½}-t\ {}^4G_{4½}$	5		w	1.625	(1.120)	1.232
2	3642.587	27445.22	$a\ {}^2P_{1½}-w\ {}^4P_{2½}$						
6d	3641.543	27453.09	$b\ {}^4P_{2½}-w\ {}^2P_{1½}$						
30, V	3640.638	27459.92	$a\ {}^2D_{1½}-276\ \frac{1}{2}_{5}$	4	0.494	0.247	0.632	1.867	1.373
40c, V	3639.335	27469.75	$a\ {}^4G_{3½}-t\ {}^4G_{3½}$	6		0.41uv	1.21	(1.26)	1.16
20c, V	3638.792	27473.85	$a\ {}^4F_{4½}-x\ {}^4F_{4½}$						
2c	3638.673	27474.74	$a\ {}^4D_{1½}-u\ {}^4D_{2½}$						
15c, V	3637.830	27481.11				0	1.074		
20, V	3637.545	27483.26	$a\ {}^4G_{2½}-s\ {}^4F_{3½}$	7b, 6		0	1.084	(1.081)	1.087
4	3637.306	27485.07	$a\ {}^6D_{4½}-z\ {}^3F_{3½}$						
30c, V	3636.959	27487.69	$a\ {}^4G_{4½}-v\ {}^2H_{5½}$						
2	3636.457	27491.49	$b\ {}^4F_{3½}-s\ {}^4D_{3½}$						
12c	3635.852	27496.06	$a\ {}^4H_{5½}-w\ {}^2H_{5½}$						
6c	3635.468	27498.96	$a\ {}^6D_{3½}-y\ {}^6P_{3½}$						
15	3635.328	27500.02	$a\ {}^2H_{5½}-r\ {}^2H_{5½}$	6		0.202	1.124	1.100	1.148
5	3634.604	27505.50	$a\ {}^2H_{5½}-s\ {}^2F_{4½}$						
15	3634.452	27506.65	$a\ {}^2G_{3½}-v\ {}^2G_{4½}$						
1h	3634.03	27509.85	$a\ {}^4F_{4½}-y\ {}^6P_{3½}$						
20, V	3633.717	27512.22	$a\ {}^6D_{1½}-z\ {}^5D_{2½}$ $a\ {}^4G_{3½}-u\ {}^4G_{4½}$						
15	3633.006	27517.60	$b\ {}^4F_{3½}-r\ {}^4F_{3½}$	6		--	0.876	(0.852)	0.901
4	3631.785	27526.85	$a\ {}^6D_{3½}-z\ {}^3P_{2½}$						
4	3631.338	27530.24							
5	3630.700	27535.08	$b\ {}^4P_{1½}-q\ {}^4F_{2½}$						
15	3630.623	27535.66	$a\ {}^2H_{4½}-t\ {}^2G_{4½}$	6	0.11	0.48	1.04	(0.93)	1.04
4	3628.921	27548.58	$a\ {}^2F_{3½}-s\ {}^4D_{4½}$						
8	3627.870	27556.56							
15, V	3625.717	27572.92	$b\ {}^4F_{3½}-s\ {}^4G_{4½}$						
15, V	3625.169	27577.09	$a\ {}^2D_{2½}-r\ {}^2F_{3½}$	6	0.327	0.817	1.040	1.203	0.876
7	3624.357	27583.27	$b\ {}^4D_{1½}-p\ {}^4F_{2½}$						
6c	3623.14	27592.53							
4	3622.621	27596.48							
1	3621.92	27601.82	$a\ {}^4G_{3½}-s\ {}^4F_{3½}$						
40, V	3621.030	27608.61	$a\ {}^4F_{3½}-y\ {}^4G_{4½}$	6	0.231	0.843	1.114	1.230	0.999
10	3619.207	27622.51	$a\ {}^4F_{3½}-z\ {}^4D_{3½}$						
15, V	3618.907	27624.80	$a\ {}^4P_{0½}-z\ {}^3D_{1½}$ $a\ {}^2F_{3½}-411\ \frac{1}{2}_{4½}$						
15, V	3618.441	27628.36	$a\ {}^6D_{1½}-y\ {}^4P_{1½}$						
15, V	3617.714	27633.91	$b\ {}^2H_{5½}-u\ {}^2H_{5½}$			w	1.04		

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ_{air} A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
6	3616.497	27643.22	$a\ ^6D_{1\frac{1}{2}}-z\ ^3F_{1\frac{1}{2}}$						
10	3616.216	27645.36	$a\ ^4G_{4\frac{1}{2}}-s\ ^3H_{5\frac{1}{2}}$						
4	3615.971	27647.24	$a\ ^3G_{4\frac{1}{2}}-y\ ^4H_{5\frac{1}{2}}$						
30c, V	3615.800	27650.84	$a\ ^4G_{4\frac{1}{2}}-s\ ^4F_{4\frac{1}{2}}$	6	0.100	0.450	1.148	1.198	1.098
7c	3613.45	27666.52	$a\ ^6D_{3\frac{1}{2}}-z\ ^4D_{3\frac{1}{2}}$						
9	3613.013	27669.87	$b\ ^4F_{3\frac{1}{2}}-r\ ^4F_{3\frac{1}{2}}$						
9	3612.657	27672.59	$a\ ^3D_{1\frac{1}{2}}-t\ ^4F_{1\frac{1}{2}}$						
7c	3611.285	27683.11	$b\ ^3G_{4\frac{1}{2}}-p\ ^3G_{5\frac{1}{2}}$						
7	3610.705	27687.09	$a\ ^6D_{3\frac{1}{2}}-z\ ^4D_{3\frac{1}{2}}$						
8c	3610.002	27692.95	$b\ ^4F_{1\frac{1}{2}}-r\ ^4F_{1\frac{1}{2}}$	6		0	0.424	(0.402)	0.446
9	3608.316	27705.89	$b\ ^4D_{3\frac{1}{2}}-p\ ^4F_{3\frac{1}{2}}$						
10d	3608.013	27708.21	$b\ ^4F_{4\frac{1}{2}}-r\ ^4F_{3\frac{1}{2}}$	6		0.099	1.231	1.217	1.244
7	3607.33	27713.46	$a\ ^4P_{1\frac{1}{2}}-s\ ^4D_{1\frac{1}{2}}$						
8	3606.806	27717.48	$a\ ^2D_{2\frac{1}{2}}-t\ ^4D_{1\frac{1}{2}}$						
10d	3606.492	27719.90	$b\ ^4D_{2\frac{1}{2}}-p\ ^4D_{2\frac{1}{2}}$						
8c	3606.272	27721.59	$b\ ^4F_{1\frac{1}{2}}-4001_{5\frac{1}{2}}$						
7c	3604.643	27734.12							
8c	3604.072	27738.51	$a\ ^6D_{2\frac{1}{2}}-y\ ^3G_{3\frac{1}{2}}$						
8	3603.962	27739.36	$a\ ^3P_{2\frac{1}{2}}-t\ ^3D_{1\frac{1}{2}}$						
10	3603.435	27743.41	$a\ ^2H_{4\frac{1}{2}}-s\ ^2H_{5\frac{1}{2}}$						
6	3602.876	27747.72	$b\ ^4D_{1\frac{1}{2}}-p\ ^4D_{2\frac{1}{2}}$						
2	3602.74	27748.76	$a\ ^4G_{3\frac{1}{2}}-t\ ^4G_{3\frac{1}{2}}$						
3	3602.68	27749.23	$a\ ^2D_{1\frac{1}{2}}-u\ ^4G_{2\frac{1}{2}}$						
60, III	3602.561	27750.14	$a\ ^6D_{3\frac{1}{2}}-y\ ^4P_{2\frac{1}{2}}$	4		0	1.558	(1.582)	1.601
2	3602.219	27752.78	$b\ ^4F_{3\frac{1}{2}}-q\ ^3F_{2\frac{1}{2}}$						
3	3600.678	27764.66	$a\ ^6D_{1\frac{1}{2}}-z\ ^3P_{1\frac{1}{2}}$						
20, V	3599.635	27772.70	$a\ ^4F_{3\frac{1}{2}}-y\ ^4G_{3\frac{1}{2}}$	6	0.331	0.829	1.715	1.023	0.692
20c, V	3599.279	27775.45	$b\ ^4F_{4\frac{1}{2}}-s\ ^4G_{3\frac{1}{2}}$	6		0	1.236	(1.224)	1.248
12d	3598.343	27782.67	$a\ ^6D_{2\frac{1}{2}}-y\ ^4P_{1\frac{1}{2}}$						
8	3597.514	27789.07	$a\ ^4D_{2\frac{1}{2}}-t\ ^4F_{2\frac{1}{2}}$ $a\ ^4P_{1\frac{1}{2}}-w\ ^3D_{1\frac{1}{2}}$						
16c	3597.260	27791.04	$b\ ^4F_{1\frac{1}{2}}-s\ ^4G_{1\frac{1}{2}}$						
80, III	3593.906	27816.51	$a\ ^6D_{3\frac{1}{2}}-z\ ^4S_{1\frac{1}{2}}$	4us	0.144	0.068	1.434	1.650	1.794
2	3593.543	27819.78	$b\ ^4P_{2\frac{1}{2}}-r\ ^4D_{2\frac{1}{2}}$						
3	3592.360	27828.94	$a\ ^3P_{2\frac{1}{2}}-t\ ^3D_{1\frac{1}{2}}$						
9	3591.790	27833.36	$a\ ^4F_{3\frac{1}{2}}-x\ ^4F_{3\frac{1}{2}}$						
10	3590.904	27840.23	$a\ ^6D_{3\frac{1}{2}}-z\ ^3F_{3\frac{1}{2}}$						
10c	3590.712	27841.71	$a\ ^4G_{3\frac{1}{2}}-r\ ^4F_{3\frac{1}{2}}$						
8	3589.960	27847.54	$a\ ^3D_{1\frac{1}{2}}-t\ ^4F_{2\frac{1}{2}}$						
100c, V	3589.356	27852.23	$a\ ^4F_{4\frac{1}{2}}-y\ ^4G_{3\frac{1}{2}}$	4		w	0.835	(1.330)	1.240
100, IV?	3589.106	27854.17	$a\ ^6D_{3\frac{1}{2}}-z\ ^4D_{3\frac{1}{2}}$	5		--	1.882	(1.582)	1.462
2	3587.942	27863.21	$b\ ^4F_{3\frac{1}{2}}-s\ ^4G_{3\frac{1}{2}}$						
9d	3587.400	27867.42	$a\ ^4G_{3\frac{1}{2}}-t\ ^4G_{3\frac{1}{2}}$						
6	3586.869	27871.54	$a\ ^4G_{3\frac{1}{2}}-s\ ^4F_{3\frac{1}{2}}$						
4	3586.695	27872.89	$a\ ^4G_{3\frac{1}{2}}-4001_{5\frac{1}{2}}$						
100, IV?	3584.972	27886.29	$a\ ^6D_{2\frac{1}{2}}-y\ ^4P_{1\frac{1}{2}}$	4	0.325	0.163	1.162	1.651	1.976
4	3584.47	27890.20	$a\ ^2G_{3\frac{1}{2}}-y\ ^4H_{4\frac{1}{2}}$						
2	3583.095	27900.90	$a\ ^2H_{4\frac{1}{2}}-v\ ^2H_{5\frac{1}{2}}$						
25	3582.309	27906.55	$a\ ^4P_{2\frac{1}{2}}-s\ ^4D_{2\frac{1}{2}}$ $a\ ^2H_{4\frac{1}{2}}-s\ ^4F_{3\frac{1}{2}}$	6	0.243	0.609	1.475	1.596	1.353
10c	3582.062	27908.94	$a\ ^4G_{3\frac{1}{2}}-s\ ^4G_{3\frac{1}{2}}$						
9	3580.788	27918.87	$a\ ^6D_{3\frac{1}{2}}-z\ ^3P_{2\frac{1}{2}}$ $a\ ^2H_{5\frac{1}{2}}-s\ ^4G_{4\frac{1}{2}}$						
400r, III?	3580.277	27922.86	$a\ ^6D_{4\frac{1}{2}}-y\ ^4P_{3\frac{1}{2}}$	4	0.153	0.075	1.001	1.539	1.692
3	3579.186	27931.37	$a\ ^4H_{3\frac{1}{2}}-t\ ^4D_{2\frac{1}{2}}$						
4c	3578.586	27936.05	$a\ ^4D_{2\frac{1}{2}}-s\ ^2F_{3\frac{1}{2}}$						
3	3578.317	27938.15	$a\ ^4H_{4\frac{1}{2}}-u\ ^2G_{3\frac{1}{2}}$						
4	3578.23	27938.83	$b\ ^4F_{3\frac{1}{2}}-s\ ^4G_{3\frac{1}{2}}$						
40, V	3577.721	27942.81	$a\ ^2D_{2\frac{1}{2}}-t\ ^2D_{2\frac{1}{2}}$	6	0.125	0.313	1.141	1.204	1.078
8c	3577.238	27946.58	$b\ ^2G_{4\frac{1}{2}}-p\ ^2G_{3\frac{1}{2}}$						
200, III	3575.850	27957.43	$a\ ^6D_{3\frac{1}{2}}-y\ ^6P_{2\frac{1}{2}}$	4	0.181	0.092	1.121	1.573	1.764
20c	3575.139	27962.99	$a\ ^4G_{2\frac{1}{2}}-r\ ^4F_{1\frac{1}{2}}$						
3	3574.312	27969.46							

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ_{air} A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	7	8	10
5	3573.096	27978.98	$a\ ^3H_{3\frac{1}{2}}-t\ ^4G_{3\frac{1}{2}}$						
1	3572.10	27986.78	$b\ ^3G_{3\frac{1}{2}}-o\ ^4D_{2\frac{1}{2}}$						
6c	3571.485	27991.60	$a\ ^4G_{3\frac{1}{2}}-400_{3\frac{1}{2}}$						
3	3571.124	27994.42	$a\ ^3D_{2\frac{1}{2}}-r\ ^3F_{3\frac{1}{2}}$						
7c	3569.854	28004.39	$a\ ^4G_{3\frac{1}{2}}-r\ ^4F_{3\frac{1}{2}}$						
5	3569.692	28005.66							
40, V	3569.464	28007.45	$a\ ^4F_{3\frac{1}{2}}-x\ ^4F_{3\frac{1}{2}}$	5	0.056	0.166	1.204	1.232	1.176
20, V	3568.727	28013.23	$a\ ^4F_{2\frac{1}{2}}-s\ ^4D_{2\frac{1}{2}}$	6		0*	1.564	(2.650)	0.477
5c	3567.099	28026.01	$a\ ^4D_{3\frac{1}{2}}-u\ ^4G_{3\frac{1}{2}}$						
6	3565.855	28035.79	$a\ ^4F_{3\frac{1}{2}}-y\ ^2D_{2\frac{1}{2}}$						
10c	3565.052	28042.10	$a\ ^4D_{3\frac{1}{2}}-t\ ^4F_{3\frac{1}{2}}$						
6c	3564.028	28050.16	$b\ ^4D_{3\frac{1}{2}}-q\ ^4D_{2\frac{1}{2}}$						
80, IV	3563.624	28053.34	$a\ ^6D_{3\frac{1}{2}}-y\ ^6P_{3\frac{1}{2}}$	6		0.11*	1.618	(1.652)	1.585
100, IV	3563.501	28054.31	$a\ ^6D_{1\frac{1}{2}}-z\ ^6S_{1\frac{1}{2}}$	6	0.074	0.111	1.835	1.872	1.798
6	3563.232	28056.43	$a\ ^3F_{3\frac{1}{2}}-s\ ^2G_{3\frac{1}{2}}$						
3	3562.846	28059.47	$a\ ^4H_{3\frac{1}{2}}-u\ ^3G_{3\frac{1}{2}}$						
6c	3562.649	28061.02	$a\ ^4G_{3\frac{1}{2}}-s\ ^4G_{3\frac{1}{2}}$						
6	3561.697	28068.52	$a\ ^4D_{3\frac{1}{2}}-t\ ^4F_{3\frac{1}{2}}$						
12	3561.142	28072.89	$a\ ^4G_{3\frac{1}{2}}-r\ ^4F_{3\frac{1}{2}}$						
7	3560.357	28079.08	$a\ ^6D_{3\frac{1}{2}}-z\ ^4D_{1\frac{1}{2}}$						
1	3559.470	28086.08	$b\ ^4D_{3\frac{1}{2}}-n\ ^3F_{3\frac{1}{2}}$						
12, V	3559.128	28088.78	$a\ ^4F_{2\frac{1}{2}}-w\ ^3D_{1\frac{1}{2}}$	4	1.592	0.796	0.262	2.640	1.058
9	3558.015	28097.56	$a\ ^3D_{1\frac{1}{2}}-t\ ^4D_{2\frac{1}{2}}$						
1	3557.684	28100.18	$a\ ^3F_{3\frac{1}{2}}-416_{3\frac{1}{2}}$						
2	3557.025	28105.40	$b\ ^4F_{1\frac{1}{2}}-s\ ^3D_{1\frac{1}{2}}$?						
10	3556.022	28113.31	$b\ ^4D_{3\frac{1}{2}}-p\ ^4F_{3\frac{1}{2}}$						
80, III	3554.666	28124.03	$a\ ^6D_{1\frac{1}{2}}-y\ ^6P_{1\frac{1}{2}}$	6	0.120	0.180	1.919	1.861	1.981
60, IV?	3554.524	28125.16	$a\ ^4F_{3\frac{1}{2}}-x\ ^4F_{3\frac{1}{2}}$	4		w	1.144	(1.235)	1.202
10d	3553.613	28132.37	$b\ ^4D_{3\frac{1}{2}}-p^4D_{3\frac{1}{2}}$?						
6	3552.227	28143.34	$a\ ^6D_{2\frac{1}{2}}-z\ ^5F_{3\frac{1}{2}}$						
5	3552.000	28145.14	$a\ ^4D_{3\frac{1}{2}}-u\ ^4G_{3\frac{1}{2}}$						
1	3551.37	28150.14	$a\ ^2F_{2\frac{1}{2}}-q\ ^4F_{1\frac{1}{2}}$						
8	3551.102	28152.26	$a\ ^3G_{3\frac{1}{2}}-s\ ^2F_{3\frac{1}{2}}$						
6	3550.624	28156.05	$a\ ^2D_{2\frac{1}{2}}-t\ ^4D_{2\frac{1}{2}}$						
50, IV?	3550.448	28157.45	$a\ ^6D_{2\frac{1}{2}}-z\ ^4D_{2\frac{1}{2}}$	6	0.179	0.448	1.562	1.652	1.472
10	3550.237	28159.12	$a\ ^6D_{3\frac{1}{2}}-x\ ^4D_{3\frac{1}{2}}$						
1	3549.96	28161.31	$a\ ^4D_{1\frac{1}{2}}-s\ ^3F_{2\frac{1}{2}}$						
12	3549.263	28166.84	$a\ ^2F_{2\frac{1}{2}}-s\ ^2G_{3\frac{1}{2}}$	5		0.21	1.10*	(0.86)	0.94
15, V	3548.130	28175.84	$a\ ^4F_{3\frac{1}{2}}-y\ ^4G_{3\frac{1}{2}}$	4		--	0.962	(1.029)	0.999
3	3547.426	28181.43							
2	3546.910	28185.53	$b\ ^4F_{1\frac{1}{2}}-s\ ^4D_{2\frac{1}{2}}$						
8	3546.489	28188.88	$a\ ^4F_{3\frac{1}{2}}-y\ ^2D_{2\frac{1}{2}}$						
5	3546.160	28191.49	$a\ ^4G_{3\frac{1}{2}}-r\ ^4F_{3\frac{1}{2}}$						
12	3546.031	28192.52	$a\ ^4F_{3\frac{1}{2}}-z\ ^4F_{3\frac{1}{2}}$						
6c	3545.381	28197.68	$a\ ^4G_{4\frac{1}{2}}-s\ ^4G_{3\frac{1}{2}}$						
50, IV	3544.656	28203.45	$a\ ^4P_{2\frac{1}{2}}-s\ ^4D_{1\frac{1}{2}}$	4	0.197	0.104	0.901	1.590	1.394
30, IV?	3544.031	28208.43	$a\ ^6D_{0\frac{1}{2}}-z\ ^6S_{1\frac{1}{2}}$	4	1.523	0.763	1.030	3.314	1.791
12, V	3543.936	28209.18	$a\ ^2D_{2\frac{1}{2}}-z\ ^2P_{1\frac{1}{2}}$						
8	3543.745	28210.70	$a\ ^2G_{4\frac{1}{2}}-t\ ^4F_{3\frac{1}{2}}$ $a\ ^2F_{3\frac{1}{2}}-416_{3\frac{1}{2}}$						
1	3543.55	28212.25	$a\ ^2P_{1\frac{1}{2}}-t\ ^4G_{3\frac{1}{2}}$						
15, V	3542.983	28216.77	$a\ ^4F_{1\frac{1}{2}}-y\ ^4G_{1\frac{1}{2}}$	5	0.202	0.146	--	(0.402)	0.604
10	3542.560	28220.14	$a\ ^4F_{4\frac{1}{2}}-y\ ^2F_{3\frac{1}{2}}$	5	0.200	0.105	--	(1.330)	1.130
20c	3541.898	28225.41	$b\ ^4F_{4\frac{1}{2}}-s\ ^4G_{4\frac{1}{2}}$						
15d, V	3539.650	28243.34	$a\ ^6D_{3\frac{1}{2}}-t\ ^4F_{3\frac{1}{2}}$?†			0.685	--		
2	3538.076	28255.90							
150, III	3537.475	28260.70	$a\ ^6D_{2\frac{1}{2}}-y\ ^6P_{2\frac{1}{2}}$	6	0.122	0.306	1.739	1.678	1.800
4c	3536.212	28270.80	$b\ ^4D_{2\frac{1}{2}}-u\ ^3F_{3\frac{1}{2}}$						
1	3535.845	28273.73	$b\ ^4P_{2\frac{1}{2}}-p\ ^4F_{3\frac{1}{2}}$						
400c, III	3535.304	28278.06	$a^6\ D_{3\frac{1}{2}}-y\ ^6P_{3\frac{1}{2}}$ $a\ ^6D_{3\frac{1}{2}}-y\ ^6P_{1\frac{1}{2}}$	6 4	0.124	0.425 0.674	1.642 2.616	1.580 3.326	1.704 1.986
1h	3534.85	28281.69	$b\ ^2H_{4\frac{1}{2}}-u\ ^2H_{3\frac{1}{2}}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ_{air} A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
7	3534.428	28285.07	$a\ ^3G_{3\frac{1}{2}}-t\ ^4G_{3\frac{1}{2}}$						
20c	3534.114	28287.58	$a\ ^4P_{2\frac{1}{2}}-y\ ^2P_{1\frac{1}{2}}$ $b\ ^4P_{2\frac{1}{2}}-p\ ^4D_{3\frac{1}{2}}$						
40, IV	3533.667	28291.16	$a\ ^5D_{1\frac{1}{2}}-y\ ^4P_{1\frac{1}{2}}$	4	0.261	0.134	1.226	1.878	1.617
5c	3532.521	28300.33	$a\ ^4D_{3\frac{1}{2}}-u\ ^4G_{3\frac{1}{2}}$						
7	3530.824	28313.94	$a\ ^2F_{3\frac{1}{2}}-p\ ^2F_{3\frac{1}{2}}$						
10	3530.003	28319.80	$a\ ^3H_{4\frac{1}{2}}-t\ ^4G_{3\frac{1}{2}}$						
8c	3529.394	28325.41	$a\ ^4H_{3\frac{1}{2}}-s\ ^4F_{2\frac{1}{2}}$						
10c	3528.315	28334.07	$a\ ^4D_{2\frac{1}{2}}-t\ ^4F_{1\frac{1}{2}}$	5	0.201	0.102	--	(1.420)	1.219
10	3527.959	28336.93	$a\ ^4G_{3\frac{1}{2}}-s\ ^4D_{3\frac{1}{2}}$						
6c	3527.280	28342.39	$b\ ^3H_{4\frac{1}{2}}-o\ ^4D_{3\frac{1}{2}}$						
10	3527.108	28343.77	$a\ ^4G_{3\frac{1}{2}}-r\ ^4F_{2\frac{1}{2}}$	5	0.385	0.193	--	(0.742)	1.127
2	3526.209	28350.99	$a\ ^3H_{4\frac{1}{2}}-r\ ^4F_{3\frac{1}{2}}$						
8	3525.88	28353.64	$a\ ^4P_{1\frac{1}{2}}-w\ ^2G_{1\frac{1}{2}}$						
30c, V	3525.219	28358.95	$a\ ^4G_{4\frac{1}{2}}-z\ ^4G_{3\frac{1}{2}}$	7b, 6		0	1.26	(1.26)	1.26
8	3524.93	28361.28	$a\ ^2G_{3\frac{1}{2}}-u\ ^4G_{3\frac{1}{2}}$	5		0	0.958	(0.885)	0.827
12	3523.156	28375.56	$a\ ^2D_{1\frac{1}{2}}-r\ ^2F_{2\frac{1}{2}}$	4		0	0.770	(0.953)	0.880
6	3522.787	28378.53	$b\ ^2G_{3\frac{1}{2}}-m\ ^2F_{3\frac{1}{2}}$	4		0	0.81	(0.90)	0.94
2	3522.630	28379.80	$a\ ^2H_{4\frac{1}{2}}-t\ ^4G_{3\frac{1}{2}}$						
12, V	3520.717	28395.22	$a\ ^5D_{1\frac{1}{2}}-x\ ^5D_{2\frac{1}{2}}$	4	0.381	0.197	0.898	1.851	1.470
40, IV	3520.055	28400.56	$a\ ^4F_{3\frac{1}{2}}-x\ ^4F_{3\frac{1}{2}}$	6		0	1.017	(1.229)	1.003
6	3519.337	28406.35	$a\ ^4D_{1\frac{1}{2}}-t\ ^4F_{1\frac{1}{2}}$						
8, V	3518.180	28415.69	$a\ ^5F_{3\frac{1}{2}}-q\ ^4F_{3\frac{1}{2}}$						
5	3517.84	28418.44	$a\ ^4G_{3\frac{1}{2}}-s\ ^4G_{3\frac{1}{2}}$						
12	3517.77	28419.00	$a\ ^4P_{1\frac{1}{2}}-s\ ^4D_{1\frac{1}{2}}$						
10	3517.111	28424.33	$a\ ^3F_{2\frac{1}{2}}-p\ ^2F_{3\frac{1}{2}}$						
15, V	3516.863	28426.33	$a\ ^3D_{1\frac{1}{2}}-t\ ^2D_{1\frac{1}{2}}$	6		0.055	--	(0.953)	0.916
3	3516.342	28430.54	$b\ ^2H_{4\frac{1}{2}}-u\ ^2H_{3\frac{1}{2}}$						
10	3516.198	28431.71	$a\ ^2G_{4\frac{1}{2}}-u\ ^4G_{3\frac{1}{2}}$ $b\ ^4P_{1\frac{1}{2}}-q\ ^4D_{2\frac{1}{2}}$						
3c	3514.911	28442.12	$a\ ^5D_{3\frac{1}{2}}-z\ ^5P_{2\frac{1}{2}}$						
3	3513.673	28452.14							
2	3513.545	28453.18	$a\ ^3H_{4\frac{1}{2}}-s\ ^4G_{3\frac{1}{2}}$						
1	3513.24	28455.65	$a\ ^4G_{2\frac{1}{2}}-s\ ^4D_{2\frac{1}{2}}$						
6	3512.749	28459.62	$a\ ^3G_{3\frac{1}{2}}-t\ ^4F_{2\frac{1}{2}}$						
5	3512.309	28463.19							
1	3511.614	28468.82	$a\ ^6D_{3\frac{1}{2}}-z\ ^6H_{3\frac{1}{2}}$						
20c, V	3511.189	28472.27	$a\ ^3D_{2\frac{1}{2}}-w\ ^4P_{1\frac{1}{2}}$ $a\ ^2F_{3\frac{1}{2}}-p\ ^2F_{3\frac{1}{2}}$	4 6		-- w	0.52 1.12	(1.206) (1.13)	1.67 1.11
10c	3511.13	28472.75	$a\ ^6F_{3\frac{1}{2}}-z\ ^6S_{2\frac{1}{2}}$						
1d	3510.41	28478.59							
1	3509.872	28482.95	$a\ ^4D_{1\frac{1}{2}}-u\ ^4G_{2\frac{1}{2}}$						
8c	3508.529	28493.85							
1h	3508.21	28496.44	$a\ ^4D_{2\frac{1}{2}}-t\ ^4F_{1\frac{1}{2}}$ $a\ ^4G_{4\frac{1}{2}}-r\ ^4F_{3\frac{1}{2}}$						
80, III	3507.960	28498.48	$a\ ^5D_{1\frac{1}{2}}-y\ ^6P_{2\frac{1}{2}}$	4		0*	1.610	(1.863)	1.762
10	3506.991	28506.35	$b\ ^3H_{4\frac{1}{2}}-p\ ^2G_{3\frac{1}{2}}$						
7	3506.025	28514.20	$a\ ^5D_{2\frac{1}{2}}-z\ ^5D_{2\frac{1}{2}}$						
12	3505.812	28515.94	$a\ ^5D_{1\frac{1}{2}}-t\ ^5D_{1\frac{1}{2}}$						
1	3504.59	28525.88	$a\ ^2D_{2\frac{1}{2}}-w\ ^4P_{1\frac{1}{2}}$						
20, V	3503.206	28537.15	$a\ ^3G_{4\frac{1}{2}}-x\ ^4H_{3\frac{1}{2}}$ $a\ ^4G_{2\frac{1}{2}}-s\ ^4G_{3\frac{1}{2}}$	6	0.119	0.440	1.054	1.113	0.994
8	3500.109	28562.40	$a\ ^4F_{3\frac{1}{2}}-y\ ^2F_{3\frac{1}{2}}$						
7c	3498.783	28573.22							
60d, IV	3498.631	28574.46	$a\ ^4P_{1\frac{1}{2}}-s\ ^4D_{1\frac{1}{2}}$ $a\ ^4F_{3\frac{1}{2}}-x\ ^4F_{3\frac{1}{2}}$	4	0.256	0.183	0.805	1.694	1.338
5	3498.441	28576.02	$a\ ^4H_{4\frac{1}{2}}-s\ ^4F_{3\frac{1}{2}}$						
3c	3498.358	28576.69	$a\ ^6D_{3\frac{1}{2}}-z\ ^6H_{3\frac{1}{2}}$						
30, IV	3497.815	28581.13	$a\ ^6D_{2\frac{1}{2}}-y\ ^6P_{2\frac{1}{2}}$	5		w	1.832	(1.652)	1.732
5	3497.646	28582.51	$a\ ^2F_{3\frac{1}{2}}-p\ ^2F_{3\frac{1}{2}}$						
2d	3496.284	28593.64	$a\ ^4H_{4\frac{1}{2}}-t\ ^2G_{3\frac{1}{2}}$						
20c	3496.027	28595.75	$a\ ^4G_{3\frac{1}{2}}-s\ ^4D_{2\frac{1}{2}}$						
1	3495.71	28598.34	$a\ ^4G_{2\frac{1}{2}}-q\ ^2F_{2\frac{1}{2}}$						
3d	3495.473	28600.28							
1	3495.18	28602.68	$b\ ^4D_{3\frac{1}{2}}-o\ ^2P_{1\frac{1}{2}}$						
3	3494.57	28607.67	$a\ ^4H_{3\frac{1}{2}}-t\ ^4G_{3\frac{1}{2}}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm⁻¹	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
5	3493.476	28616.63	$a\ ^3D_{3½}-t\ ^4D_{3½}$						
3	3492.56	28624.13	$b\ ^4D_{1½}-p\ ^3P_{1½}$						
15, V	3491.477	28633.01	$a\ ^4F_{1½}-y\ ^3D_{2½}$ / $b\ ^4F_{2½}-416_{3½}$						
30d, IV	3491.024	28636.73	$a\ ^4F_{1½}-x\ ^4F_{1½}$	6		0	0.411	(0.402)	0.420
1	3487.814	28663.08	$a\ ^3P_{1½}-r\ ^4F_{1½}$						
2	3487.52	28665.50	$a\ ^3D_{3½}-s\ ^4F_{1½}$						
7c	3486.724	28672.04							
12	3485.935	28678.53	$a\ ^3F_{3½}-r\ ^3G_{1½}$	5		0	1.178	(1.135)	1.151
1	3485.790	28679.72	$a\ ^4F_{4½}-x\ ^4G_{1½}$			0.14	1.09		
8	3485.102	28685.38							
3	3483.754	28696.48	$a\ ^3G_{3½}-u\ ^4G_{1½}$						
1	3483.23	28700.80	$a\ ^4D_{2½}-t\ ^4F_{1½}$						
2	3481.82	28712.42	$a\ ^6D_{4½}-y\ ^4G_{2½}$						
9	3481.265	28717.00	$a^4G_{2½}-r\ ^4F_{1½}$ / $a^4G_{2½}-q\ ^2F_{1½}$						
15, V	3481.054	28718.74	$a\ ^4P_{2½}-v\ ^4D_{1½}$	4	1.434	0.718	0.508	2.660	1.225
40, V	3478.690	28738.25	$a\ ^4P_{1½}-x\ ^4P_{1½}$	6		0	1.574	(1.596)	1.552
4	3478.335	28741.19	$a\ ^3D_{1½}-t\ ^3D_{1½}$						
8	3478.010	28743.88	$a\ ^3D_{1½}-x\ ^3P_{0½}$	5	0.391	0.194	1.153	0.957	0.566
1	3477.92	28744.62	$a\ ^3D_{2½}-u\ ^3G_{1½}$						
1	3477.26	28750.07	$b\ ^4F_{4½}-s\ ^2G_{1½}$						
1	3476.655	28755.08	$a\ ^4H_{2½}-p\ ^2H_{1½}$						
10c	3475.990	28760.58	$a\ ^4H_{3½}-s\ ^4F_{2½}$	5		0	1.143	(1.12)	1.11
15, V	3475.590	28763.89	$b\ ^4F_{2½}-q\ ^4F_{2½}$	4		0h	0.964	(1.120)	1.245
1	3474.99	28768.85	$b\ ^4F_{3½}-414_{3½}$						
5c	3473.362	28782.34	$a\ ^4G_{4½}-411_{3½}$						
7	3473.125	28784.30	$a\ ^4G_{3½}-s\ ^4G_{1½}$						
30c, V	3473.020	28785.17	$b\ ^4F_{4½}-q\ ^4F_{3½}$	5		0	1.291	(1.224)	1.186
5	3472.776	28787.19	$a\ ^4P_{2½}-v\ ^2D_{1½}$						
9	3471.526	28797.56	$a\ ^3G_{3½}-x\ ^4H_{3½}$						
10	3471.198	28800.28	$b\ ^3G_{3½}-p\ ^3G_{3½}$	6		0.239	0.872	0.906	0.838
5	3471.036	28801.62	$a^2F_{2½}-s\ ^2D_{2½}$ / $a^4H_{4½}-v\ ^2H_{1½}$						
15, V	3469.442	28814.86	$a\ ^2G_{4½}-x\ ^4H_{3½}$	5		0	1.120	(1.103)	1.108
3	3469.244	28816.50	$a\ ^4G_{3½}-s\ ^4D_{2½}$						
7	3469.135	28817.41	$a\ ^6D_{3½}-x\ ^4D_{2½}$						
3	3468.942	28819.01	$a\ ^2H_{4½}-s\ ^4G_{4½}$						
8	3468.549	28822.28	$a\ ^4D_{2½}-t\ ^2D_{1½}$						
15, V	3467.474	28831.24	$a\ ^6D_{1½}-t\ ^4D_{0½}$	5	1.101	0.551	1.743	1.192	0.081
2	3466.231	28841.55	$a^4H_{4½}-t\ ^4G_{3½}$ / $b\ ^4F_{4½}-p\ ^2F_{2½}$						
30, IV	3465.860	28844.64	$a\ ^4F_{1½}-x\ ^4F_{2½}$	5	0.603	0.303	1.911	0.403	1.006
3	3465.610	28846.72	$b\ ^4F_{3½}-p\ ^2F_{2½}$						
25c, V	3463.813	28861.68	$a\ ^4G_{3½}-q\ ^4F_{3½}$	5		w	1.55—	(1.26)	1.20
8, V	3463.685	28862.75	$b\ ^4F_{3½}-q\ ^4F_{3½}$	5	0.302	0.150	1.309	0.856	0.554
10, V	3463.033	28868.18	$a\ ^2H_{3½}-s\ ^4G_{3½}$						
15, V	3462.647	28871.40	$a^4F_{3½}-y\ ^2F_{3½}$ / $b\ ^4F_{3½}-r\ ^4F_{3½}$	6	0.101	0.354	1.205	1.259	1.158
5	3461.61	28880.05	$a\ ^6D_{3½}-z\ ^4H_{3½}$						
5	3460.66	28887.98	$a\ ^4P_{1½}-p\ ^4G_{2½}$						
25, V	3459.702	28895.98	$a\ ^4D_{3½}-t\ ^4D_{3½}$	5		0	1.580	(1.420)	1.356
12, V	3458.951	28902.25	$a\ ^4P_{1½}-x\ ^4P_{1½}$	7b, 5		0	1.601	(1.596)	1.589
5	3458.87	28902.93	$a\ ^3G_{4½}-r\ ^3F_{3½}$						
7	3458.740	28904.01	$a\ ^4P_{0½}-y\ ^2P_{0½}$						
20, V	3457.801	28911.86	$a\ ^4D_{3½}-t\ ^4D_{3½}$	5	0.309	0.154	1.824	1.360	1.053
2	3457.205	28916.85	$a\ ^4F_{1½}-z\ ^6S_{2½}$						
5h	3456.993	28918.62	$b\ ^3G_{4½}-t\ ^2H_{3½}$?						
12, V	3456.543	28922.38	$a\ ^3G_{4½}-y\ ^3H_{3½}$	4	0.120	0.060	0.400	(1.103)	0.983
2	3453.425	28948.50	$b\ ^4F_{3½}-q\ ^4F_{3½}$						
3c	3453.08	28951.39	$a\ ^4D_{3½}-w\ ^2H_{3½}$						
15c	3452.652	28954.98	$a\ ^4P_{1½}-y\ ^2P_{1½}$						
20c, V	3452.373	28957.32	$a\ ^4H_{3½}-t\ ^4G_{3½}$						
3c	3451.12	28967.83							
1	3448.76	28987.65	$a\ ^3G_{3½}-r\ ^3F_{3½}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ_{air} A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
1	3447.843	28995.36	a $^4F_{3½}$–z $^3G_{3½}$						
3	3446.747	29004.58	a $^5G_{3½}$–t $^4F_{4½}$						
1	3446.382	29007.65	a $^5D_{1½}$–x $^3P_{1½}$						
40c, V	3445.67	29013.65	a $^4G_{4½}$–s $^4G_{3½}$	5		0	1.293	(1.23)	1.25
10	3442.800	29037.83	a $^3H_{4½}$–411 $y_{4½}$	5		--	1.62–	(0.93)	0.73
12, V	3442.655	29039.06	a $^3G_{3½}$–x $^1H_{3½}$	5		w	1.378	(0.885)	0.995
4	3439.702	29063.99	a $^4G_{3½}$–w $^3P_{1½}$						
8	3439.342	29067.03	a $^5D_{4½}$–y $^4G_{5½}$						
15, V, Cb II	3436.964	29087.14	a $^4H_{3½}$–400 $z_{4½}$						
3h	3435.04	29103.43							
4	3434.118	29111.24	a $^5D_{4½}$–x $^4F_{5½}$						
6	3433.18	29119.20	b $^5G_{4½}$–t $^3H_{4½}$						
12, V	3433.099	29119.88	a $^5G_{4½}$–w $^3H_{5½}$						
15c, V	3432.420	29125.64	a $^4D_{2½}$–t $^4D_{2½}$						
10, V	3431.955	29129.59	a $^4F_{2½}$–y $^2F_{3½}$						
8d	3431.064	29137.15	a $^4D_{3½}$–t $^3D_{3½}$						
20, V	3429.059	29154.19	a $^4P_{2½}$–x $^4S_{1½}$	4	0.214	0.109	1.267	1.588	1.802
15c, V	3428.795	29156.44	a $^4H_{3½}$–s $^4G_{3½}$						
7	3428.369	29160.06	a $^4D_{1½}$–t $^3D_{1½}$						
50, IV	3427.454	29167.84	a $^5_2F_{4½}$–v $^4F_{3½}$	7b, 4		0	1.325	(1.330)	1.333
4c	3426.730	29174.00	a $^4H_{3½}$–t $^4G_{3½}$						
30c, V	3425.855	29181.46	a $^4G_{3½}$–r $^2G_{3½}$	5		w	1.610	(1.26)	1.18
30, IV	3423.765	29199.27	a $^4F_{4½}$–x $^4G_{3½}$	6	0.164	0.746	1.248	1.329	1.165
2h	3423.23	29203.83	a $^2F_{3½}$–r $^4D_{3½}$						
1	3422.35	29211.34	b $^4F_{2½}$–r $^2G_{3½}$						
1	3422.119	29213.30	a $^4P_{2½}$–u $^3F_{3½}$						
4	3420.287	29228.96	a $^5D_{4½}$–x $^4F_{3½}$						
7d	3420.11	29230.47							
1	3419.148	29238.70	b $^4F_{3½}$–q $^4F_{3½}$						
15, V	3417.867	29249.65	a $^4D_{1½}$–t $^4D_{1½}$	6	0.145	0.211	1.123	1.195	1.050
5	3417.272	29254.75	a $^4P_{2½}$–y $^2P_{1½}$						
30c, V	3415.984	29265.78	a $^4D_{3½}$–w $^4P_{1½}$	4	0.158	0.079	1.012	1.407	1.565
4	3415.603	29269.04	a $^3H_{4½}$–s $^4G_{5½}$						
15, V	3414.070	29282.18	a $^4F_{4½}$–w $^2F_{3½}$	5	0.249	0.123	2.198	1.327	1.078
10d	3413.51	29286.99	a $^4H_{3½}$–r $^4F_{3½}$						
15, V	3409.915	29317.86	a $^4H_{4½}$–r $^4F_{3½}$	4	0.150	--	0.483	(0.984)	1.134
50, IV	3408.380	29331.07	a $^4F_{3½}$–z $^4G_{3½}$	6	0.232	--	1.130	1.246	1.014
10	3407.980	29334.51	b $^4F_{3½}$–s $^3D_{3½}$						
10, V	3406.616	29346.28	a $^4P_{1½}$–z $^4P_{½}$	4	0.318	0.159	1.890	1.731	2.049
40, V	3406.140	29350.36	a $^4D_{3½}$–t $^4D_{4½}$	7b, 6		0	1.364	(1.360)	1.368
60, V	3405.418	29356.58	a $^4D_{3½}$–t $^4D_{3½}$	6	0.127	0.375	1.368	1.432	1.305
4	3404.512	29364.39	a $^6D_{3½}$–z $^6S_{2½}$						
10, V	3403.785	29370.91	a $^2H_{3½}$–q $^4F_{3½}$	4		--	0.720	(1.652)	0.974
15c, V	3403.013	29377.33							
1	3402.40	29382.62	a $^3D_{3½}$–s $^4F_{3½}$						
10, V	3399.967	29403.64	a $^4D_{2½}$–x $^2P_{1½}$	5		0h	1.468h	(1.360)	1.288
25, IV	3399.399	29408.56	a $^4F_{4½}$–x $^3G_{5½}$	6	0.237	1.064	1.217	1.335	1.099
15, V	3398.254	29418.46				0	1.20		
2	3397.836	29422.08	a $^6D_{3½}$–y $^4G_{5½}$						
1	3397.43	29425.60	a $^4H_{4½}$–q $^2F_{3½}$						
40, IV	3395.928	29438.61	a $^4F_{2½}$–y $^2F_{3½}$	5		--	1.367	(1.029)	1.126
4	3395.455	29442.71	a $^4G_{2½}$–414 $j_{3½}$						
6	3394.217	29453.45							
12	3394.060	29454.55	a $^4D_{3½}$–t $^2D_{2½}$						
2	3393.679	29458.12	b $^4F_{1½}$–q $^4F_{1½}$						
100, IV	3392.345	29469.71	{a $^4F_{3½}$–z $^4G_{3½}$ / a$^2H_{4½}$–s $^3G_{3½}$	6 / 4	0.408	1.019 / 0	0.834 / --	1.034 / (0.93)	0.636 / --
4	3391.732	29475.03	a $^4D_{1½}$–t $^2D_{2½}$						
7	3391.429	29477.66	a $^4D_{1½}$–z $^2P_{½}$						
10	3391.332	29478.51	a $^4G_{3½}$–416 $j_{4½}$						
25c, V	3390.623	29484.67	a $^4D_{3½}$–u $^3G_{3½}$	4	0.403	0.609	--	(1.420)	1.017
7c	3390.413	29486.50							

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
1c	3390.08	29489.39	$a\ ^3F_{2½}-p\ ^4F_{1½}$						
1	3389.73	29492.44	$b\ ^3G_{4½}-o\ ^3G_{3½}$						
15, V	3387.754	29509.64	$a\ ^4P_{1½}-y\ ^2S_{½}$	4	0.356	0.178	1.587	1.724	2.080
10, V	3387.579	29511.16	$a\ ^4H_{4½}-s\ ^4G_{3½}$	4		--	0.646	(0.984)	1.080
20	3386.995	29516.25	$a\ ^4G_{4½}-q\ ^4F_{4½}$						
10	3385.815	29526.54							
12, V	3385.665	29527.85	$a\ ^4F_{4½}-w\ ^4F_{3½}$						
4	3385.192	29531.97	$a\ ^4P_{2½}-p\ ^3D_{2½}$						
20, V	3384.662	29536.60	$a\ ^4G_{2½}-q\ ^4F_{1½}$	5	0.200	0.098	1.058	0.758	0.558
1h	3384.50	29538.01	$a\ ^4G_{4½}-s\ ^3G_{3½}$						
15, V	3383.802	29544.10	$a\ ^4D_{3½}-t\ ^4D_{1½}$						
2	3382.91	29551.89	$b\ ^3G_{3½}-r\ ^4G_{2½}$						
20	3380.862	29569.80	$a\ ^4P_{1½}-z\ ^4P_{1½}$						
7	3380.490	29573.04	$a\ ^4G_{4½}-q\ ^4F_{3½}$						
40, III	3380.420	29573.66	$a\ ^4F_{1½}-y\ ^3F_{1½}$	5	0.475	0.234	1.604	0.416	0.891
20, V	3380.055	29576.86	$a\ ^4F_{4½}-z\ ^4I_{3½}$	4	0.330	0.165	--	(1.330)	1.000
6	3377.743	29597.10	$a\ ^4G_{3½}-4165_{3½}$						
15, IV	3376.732	29605.96	$a\ ^4H_{3½}-r\ ^4F_{1½}$						
1	3376.59	29607.20	$a\ ^6D_{4½}-y\ ^4G_{3½}$						
12, IV	3376.341	29609.39	$a\ ^4G_{3½}-q\ ^4F_{2½}$						
60, IV	3374.928	29621.78	$a\ ^3G_{3½}-w\ ^3H_{3½}$	5		w	1.111	(0.885)	0.935
5	3374.029	29629.68	$a\ ^4G_{4½}-p\ ^3F_{2½}$						
1	3373.71	29632.48	$a\ ^4H_{3½}-s\ ^4G_{2½}$						
5	3372.164	29646.06	$a\ ^4P_{2½}-x\ ^4P_{2½}$						
10 V	3372.101	29646.62	$a\ ^4F_{4½}-u\ ^4F_{3½}$ $a\ ^4F_{3½}-x\ ^3G_{3½}$						
40, IV	3371.331	29653.39	$a\ ^4F_{3½}-v\ ^4F_{1½}$ $a\ ^3G_{4½}-u\ ^3G_{3½}$	5	0.184	0.092	1.700	1.240	1.056
20d	3369.840	29666.51	$a\ ^4D_{3½}-w\ ^4P_{1½}$						
4	3369.719	29667.57	$a\ ^6D_{2½}-z\ ^6S_{1½}$						
20c	3369.081	29673.19	$a\ ^4H_{5½}-s\ ^4G_{4½}$						
10d	3368.426	29678.96	$b\ ^3H_{3½}-t\ ^3H_{3½}$						
25, V	3367.382	29688.16	$a\ ^4D_{1½}-t\ ^4D_{½}$	5		0A	1.602	(1.197)	1.359
8	3367.085	29690.78	$a\ ^3H_{4½}-r\ ^3G_{3½}$						
50, IV	3366.956	29691.92	$a\ ^3G_{4½}-w\ ^3H_{3½}$	4		0	1.041	(1.103)	1.084
6	3365.883	29701.38							
15d	3363.750	29720.22	$a\ ^4D_{2½}-w\ ^4P_{1½}$	6		0.606	--	(1.360)	1.602
10	3362.866	29728.03	$a\ ^4G_{3½}-q\ ^4F_{2½}$						
2d	3361.86	29736.92	$b\ ^4F_{1½}-r\ ^4D_{1½}$						
2	3361.35	29741.44	$a\ ^4D_{1½}-z\ ^3P_{1½}$						
7	3359.874	29754.50	$a\ ^4P_{2½}-p\ ^3D_{1½}$						
4	3358.77	29764.28	$a\ ^3P_{1½}-w\ ^3P_{1½}$						
250r, III	3358.422	29767.37	$a\ ^4F_{4½}-z\ ^4G_{3½}$	4		w	0.826	(1.330)	1.238
4d	3357.899	29772.00	$a\ ^4D_{3½}-x\ ^3P_{2½}$ $a\ ^3H_{4½}-q\ ^4F_{3½}$						
25, V	3357.043	29779.59	$a\ ^4F_{3½}-w\ ^3F_{2½}$	5	0.256	0.128	1.878	1.238	0.982
1	3356.76	29782.10	$a\ ^3F_{2½}-p\ ^4D_{1½}$						
8c	3356.465	29784.72							
12, V	3355.423	29793.97	$a\ ^4G_{2½}-q\ ^4F_{1½}$	6		0.437	--	(1.081)	1.186
80, III	3354.743	29800.01	$a\ ^4F_{4½}-v\ ^4F_{3½}$	6	0.116	0.554	1.272	1.330	1.214
6d	3353.675	29809.50	$a\ ^4P_{2½}-y\ ^2S_{½}$ $a\ ^4H_{4½}-r\ ^4F_{3½}$						
7d	3353.352	29812.37	$a\ ^4H_{3½}-q\ ^3F_{2½}$						
10c	3352.868	29816.67							
15, V	3352.592	29819.13	$a\ ^4F_{3½}-v\ ^4F_{2½}$						
12, V	3352.282	29821.88	$a\ ^4P_{1½}-x\ ^2S_{½}$	6	0.093	0.140	1.79°	(1.721)	1.814
3c	3351.819	29826.00							
1	3351.511	29828.74	$a\ ^4H_{4½}-q\ ^4F_{4½}$						
2h	3351.33	29830.36	$b\ ^3D_{2½}-m\ ^3F_{2½}$						
7c	3350.689	29836.06	$a\ ^4G_{4½}-r\ ^3G_{3½}$						
4	3350.048	29841.77	$a\ ^3D_{2½}-s\ ^4G_{2½}$						
40c, V	3349.324	29846.44	$a\ ^4H_{5½}-s\ ^4G_{4½}$	4		0A	1.14	(1.22)	1.25
200, III	3349.068	29850.50	$a\ ^4F_{3½}-x\ ^4G_{3½}$	4		w	0.958	(1.235)	1.134
4	3348.082	29859.29	$a\ ^4F_{2½}-w\ ^4F_{2½}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
6	3347.558	29863.97	$a\ {}^4P_{3½}-u\ {}^2D_{2½}$						
25, V	3346.935	29869.53	$a\ {}^4P_{2½}-x\ {}^4F_{1½}$	4	1.053	0.526	1.068	2.648	1.595
1	3346.09	29877.07	$a\ {}^4H_{4½}-s\ {}^4G_{3½}$						
5	3345.949	29878.33							
2c	3345.40	29883.23	$a\ {}^4D_{3½}-u\ {}^2G_{3½}$						
4	3345.178	29885.20	$a\ {}^2H_{4½}-p\ {}^2F_{3½}$						
3	3343.90	29896.64							
150r, III	3343.712	29898.32	$a\ {}^4F_{4½}-x\ {}^4G_{3½}$	4			0h	0.984	(1.029) 1.009
4	3342.912	29905.47	$a\ {}^6D_{1½}-z\ {}^8S_{2½}$						
2	3342.48	29909.35	$a\ {}^4H_{4½}-s\ {}^4D_{3½}$						
4	3342.369	29910.33	$183_{3½}-o\ {}^2G_{3½}$						
200r, III	3341.982	29913.79	$a\ {}^4F_{1½}-x\ {}^4G_{2½}$	5	0.221	0.111	0.964	0.410	0.631
6	3339.783	29933.49	$a\ {}^4F_{3½}-w\ {}^2F_{3½}$						
8	3339.268	29938.10	$a\ {}^2F_{3½}-n\ {}^2F_{3½}$						
12c	3339.158	29939.09	$a\ {}^4D_{2½}-u\ {}^2G_{3½}$						
4	3337.87	29950.64	$b\ {}^4F_{3½}-q\ {}^4D_{3½}$						
15, V	3336.321	29964.55	$a\ {}^4F_{2½}-w\ {}^4F_{1½}$	5?	0.523	0.270	--	(1.029)	0.506
20c, V	3335.420	29972.64							
10	3333.970	29985.68	$a\ {}^4F_{3½}-u\ {}^4F_{3½}$						
15	3332.704	29997.07	$a\ {}^4F_{4½}-w\ {}^4G_{3½}$						
25, IV	3332.164	30001.93	$a\ {}^4F_{3½}-z\ {}^4\Pi_{3½}$	4	0.400	0.197	−0.594	(1.235)	0.835
10	3331.895	30004.35	$a\ {}^4D_{1½}-w\ {}^4P_{1½}$						
1h	3331.67	30006.38	$b\ {}^4F_{3½}-o\ {}^4D_{3½}$						
10	3329.622	30024.83	$a\ {}^4D_{1½}-w\ {}^4P_{2½}$						
40, V	3329.364	30027.16	$a\ {}^2G_{3½}-t\ {}^4D_{3½}$	6	0.405	1.421	1.006	0.892	1.299
1	3328.844	30031.85	$a\ {}^4F_{1½}-y\ {}^4S_{1½}$						
6	3328.398	30035.88	$a\ {}^4D_{2½}-z\ {}^2P_{1½}$						
6	3328.163	30038.00	$a\ {}^2F_{3½}-n\ {}^2F_{2½}$						
10	3327.923	30040.16	$b\ {}^4F_{3½}-p\ {}^4F_{3½}$						
4	3326.745	30050.80	$a\ {}^4P_{2½}-u\ {}^4D_{1½}$						
50, IV	3326.621	30051.92	$a\ {}^2G_{4½}-u\ {}^2G_{3½}$	7b, 6		0	1.103	(1.103)	1.103
1	3326.077	30056.83	$a\ {}^4G_{3½}-r\ {}^2G_{3½}$						
1	3325.946	30058.02	$a\ {}^4D_{1½}-w\ {}^4P_{1½}$						
6	3325.744	30059.84	$a\ {}^4F_{2½}-x\ {}^2G_{3½}$						
8	3322.816	30086.33							
4c	3322.68	30087.56							
6	3322.245	30091.50	$a\ {}^2H_{4½}-r\ {}^2G_{3½}$ $a\ {}^2D_{1½}-t\ {}^4G_{3½}$						
2	3322.00	30093.72	$a\ {}^4F_{4½}-x\ {}^2F_{3½}$						
4	3321.53	30097.98	$a\ {}^2G_{4½}-t\ {}^2G_{3½}$						
40, V	3319.265	30118.51	$a\ {}^4F_{4½}-w\ {}^4F_{3½}$						
50, IV	3318.982	30121.08	$a\ {}^4F_{3½}-v\ {}^4F_{3½}$	5		?	1.328	(1.029)	0.830
2	3318.461	30125.81	$b\ {}^2H_{4½}-t\ {}^2H_{3½}$ $a\ {}^4D_{2½}-t\ {}^4D_{3½}$						
1	3315.979	30148.36	$a\ {}^2F_{3½}-n\ {}^2F_{3½}$						
40, V	3315.226	30155.21	$a\ {}^2G_{3½}-u\ {}^2G_{3½}$	6	0.130	0.385	0.936	0.871	1.001
120, IV	3312.607	30179.05	$a\ {}^4F_{3½}-w\ {}^4F_{3½}$	6		0.117	1.218	1.238	1.198
1c	3311.95	30185.03	$b\ {}^4F_{3½}-q\ {}^4D_{3½}$						
2c	3311.75	30186.86	$b\ {}^4F_{4½}-q\ {}^4D_{3½}$						
15, V	3311.341	30190.59	$b\ {}^4F_{3½}-p\ {}^4F_{3½}$	6	0.097	0.288	1.168	(1.120)	1.217
25, IV	3310.469	30198.54	$a\ {}^4F_{4½}-w\ {}^4D_{3½}$	4		0	1.317	(1.330)	1.337
2	3310.37	30199.44	$a\ {}^4P_{1½}-v\ {}^2D_{2½}$						
5	3310.097	30201.93	$b\ {}^4F_{2½}-p\ {}^4F_{1½}$						
6	3309.805	30204.60	$b\ {}^4F_{3½}-p\ {}^4D_{2½}$						
2	3309.617	30206.31	$b\ {}^2G_{4½}-o\ {}^2G_{3½}$						
1	3308.78	30213.96	$a\ {}^4F_{4½}-x\ {}^2G_{3½}$						
2	3308.710	30214.59	$a\ {}^4P_{2½}-u\ {}^4D_{2½}$						
40, IV	3308.050	30220.62	$a\ {}^4F_{3½}-v\ {}^4F_{2½}$	6		0	1.035	(1.029)	1.041
3	3306.778	30232.25	$a\ {}^2D_{2½}-q\ {}^2F_{2½}$						
1	3306.29	30236.71	$a\ {}^2P_{1½}-q\ {}^4F_{1½}$						
20, V	3304.836	30250.01	$b\ {}^4F_{3½}-p\ {}^4F_{3½}$	6	0.064	0.235	1.244	1.212	1.276
3c	3303.07	30266.18							
1h	3302.80	30268.66	$b\ {}^4F_{4½}-p\ {}^4D_{3½}$						
3	3302.48	30271.58	$b\ {}^4P_{2½}-o\ {}^4D_{2½}$						
15c	3302.183	30274.31				0.117h−			
30, IV	3299.608	30297.94	$a\ {}^4F_{3½}-u\ {}^4F_{3½}$	6	0.106	0.405	1.16	(1.235)	1.119
4	3298.977	30303.73							

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
12	3298.410	30308.94	$a\ ^3G_{4\frac{1}{2}}-t\ ^3G^0_{3\frac{1}{2}}$						
8c	3297.286	30319.27	$a\ ^4D_{2\frac{1}{2}}-w\ ^4P^0_{1\frac{1}{2}}$						
10	3296.478	30326.70	$b\ ^2H_{4\frac{1}{2}}-t\ ^2H^0_{5\frac{1}{2}}$						
80, IV	3295.025	30330.87	$a\ ^4F_{3\frac{1}{2}}-u\ ^4F^0_{4\frac{1}{2}}$	6	0.096	0.355	1.269	1.317	1.221
1	3294.250	30347.21	$a\ ^4F_{2\frac{1}{2}}-w\ ^4G^0_{3\frac{1}{2}}$						
2h	3292.806	30360.52	$b\ ^4F_{2\frac{1}{2}}-n\ ^2F^0_{3\frac{1}{2}}$						
10, V	3291.921	30368.68	$a\ ^4P_{2\frac{1}{2}}-u\ ^4D^0_{3\frac{1}{2}}$						
1h	3290.30	30383.64	$a\ ^4G_{4\frac{1}{2}}-p\ ^4F^0_{4\frac{1}{2}}$						
15	3290.007	30386.35	$a\ ^4F_{3\frac{1}{2}}-v\ ^4F^0_{3\frac{1}{2}}$						
8	3289.460	30391.40	$a\ ^4F_{2\frac{1}{2}}-w\ ^4D^0_{2\frac{1}{2}}$?			0.20	--		
3h	3288.19	30403.14							
40, V	3287.923	30405.61	$a\ ^4P_{2\frac{1}{2}}-w\ ^4S^0_{1\frac{1}{2}}$	4	0.352	0.176	1.068	1.596	1.948
2h	3287.72	30407.48	$b\ ^4F_{3\frac{1}{2}}-n\ ^2F^0_{3\frac{1}{2}}$						
50, IV	3287.592	30408.67	$a\ ^4F_{1\frac{1}{2}}-w\ ^4F^0_{1\frac{1}{2}}$	6	0.097	0.145	0.452	0.403	0.501
60, IV	3285.668	30426.48	$a\ ^4F_{2\frac{1}{2}}-w\ ^4F^0_{2\frac{1}{2}}$			0	1.018	(1.029)	1.007
1	3285.488	30428.14	$a\ ^2P_{1\frac{1}{2}}-q\ ^4F^0_{1\frac{1}{2}}$						
3	3285.381	30429.14							
1	3284.81	30434.42	$b\ ^4P_{0\frac{1}{2}}-v\ ^2P^0_{1\frac{1}{2}}$						
5	3282.990	30451.29	$a\ ^4F_{3\frac{1}{2}}-v\ ^4F^0_{4\frac{1}{2}}$						
1	3282.608	30454.84	$a\ ^4G_{2\frac{1}{2}}-q\ ^4D^0_{1\frac{1}{2}}$						
8	3279.826	30480.67	$b\ ^4F_{2\frac{1}{2}}-p\ ^4F^0_{3\frac{1}{2}}$						
4	3278.599	30492.08	$a\ ^4D_{0\frac{1}{2}}-s\ ^4F^0_{1\frac{1}{2}}$						
1	3278.307	30494.79	$\begin{cases} b\ ^4F_{2\frac{1}{2}}-p\ ^4D^0_{2\frac{1}{2}} \\ a\ ^2P_{1\frac{1}{2}}-y\ ^4H^0_{2\frac{1}{2}} \end{cases}$						
50, IV	3277.676	30500.66	$a\ ^4F_{2\frac{1}{2}}-w\ ^2F^0_{3\frac{1}{2}}$	5		0h	1.174	(1.029)	1.070
4	3276.567	30510.99	$\begin{cases} a\ ^4D_{2\frac{1}{2}}-s\ ^4F^0_{2\frac{1}{2}} \\ a\ ^2P_{1\frac{1}{2}}-p\ ^2F^0_{2\frac{1}{2}} \end{cases}$						
2	3276.304	30513.43	$b\ ^4F_{1\frac{1}{2}}-p\ ^4D^0_{2\frac{1}{2}}$						
5	3275.960	30516.64	$a\ ^2G_{4\frac{1}{2}}-v\ ^2H^0_{5\frac{1}{2}}$						
2	3274.355	30531.60	$a\ ^4P_{1\frac{1}{2}}-u\ ^2D^0_{2\frac{1}{2}}$						
3	3273.139	30542.94	$a\ ^4D_{1\frac{1}{2}}-s\ ^4F^0_{2\frac{1}{2}}$						
25, IV	3272.074	30552.88	$a\ ^4F_{1\frac{1}{2}}-u\ ^4F^0_{2\frac{1}{2}}$	6		0	1.021	(1.029)	1.013
10, V	3271.982	30553.74	$a\ ^2G_{3\frac{1}{2}}-u\ ^2G^0_{3\frac{1}{2}}$						
20, IV	3270.761	30565.14	$a\ ^4F_{1\frac{1}{2}}-v\ ^4F^0_{1\frac{1}{2}}$						
25, IV	3270.465	30567.91							
3c	3269.493	30576.99	$a\ ^4D_{3\frac{1}{2}}-s\ ^4F^0_{4\frac{1}{2}}$						
2	3268.946	30582.11	$a\ ^4G_{2\frac{1}{2}}-r\ ^4D^0_{2\frac{1}{2}}$?						
15, V	3267.052	30599.84	$a\ ^2G_{3\frac{1}{2}}-t\ ^2G^0_{4\frac{1}{2}}$	6		0	0.895	(0.885)	0.905
9	3266.413	30605.83	$b\ ^4F_{1\frac{1}{2}}-p\ ^4F^0_{1\frac{1}{2}}$						
6c	3266.008	30609.62	$b\ ^2G_{3\frac{1}{2}}-o\ ^2G^0_{3\frac{1}{2}}$	6		0	0.88	0.85	(0.91)
5	3265.313	30616.14							
40, IV	3264.597	30622.85	$a\ ^4F_{0\frac{1}{2}}-w\ ^4G^0_{1\frac{1}{2}}$			0w	1.004	(1.330)	1.271
2	3264.261	30626.01	$a\ ^4H_{3\frac{1}{2}}-q\ ^4F^0_{3\frac{1}{2}}$						
3	3263.793	30630.40	$a\ ^4P_{1\frac{1}{2}}-u\ ^2D^0_{2\frac{1}{2}}$						
20, V	3260.139	30664.73	$a\ ^4F_{1\frac{1}{2}}-v\ ^4F^0_{2\frac{1}{2}}$	5	0.638	0.322		(0.402)	1.040
6	3259.140	30674.13	$a\ ^2G_{4\frac{1}{2}}-v\ ^2H^0_{5\frac{1}{2}}$	5		0	1.288	(1.103)	1.160
1	3257.17	30692.68	$a\ ^4H_{3\frac{1}{2}}-416^0_{3\frac{1}{2}}$						
3c	3257.004	30694.24	$b\ ^4P_{1\frac{1}{2}}-o\ ^4D^0_{2\frac{1}{2}}$						
1	3256.03	30703.42	$a\ ^2G_{3\frac{1}{2}}-t\ ^4G^0_{3\frac{1}{2}}$						
2	3254.71	30715.88	$a\ ^2D_{2\frac{1}{2}}-s\ ^4D^0_{1\frac{1}{2}}$						
2	3254.455	30718.28	$a\ ^4P_{1\frac{1}{2}}-u\ ^4D^0_{1\frac{1}{2}}$						
1h	3253.45	30727.77	$b\ ^4P_{1\frac{1}{2}}-o\ ^4D^0_{1\frac{1}{2}}$						
4d	3253.339	30728.82	$b\ ^4D_{3\frac{1}{2}}-r\ ^4G^0_{3\frac{1}{2}}$						
7c	3252.771	30734.19	$b\ ^4F_{1\frac{1}{2}}-p\ ^4F^0_{2\frac{1}{2}}$						
30, IV	3251.630	30744.97	$a\ ^4F_{2\frac{1}{2}}-v\ ^2F^0_{3\frac{1}{2}}$	6	0.070	0.210	1.202	1.237	1.167
9, V	3251.490	30746.29	$a\ ^4F_{2\frac{1}{2}}-w\ ^4F^0_{2\frac{1}{2}}$						
1	3250.897	30751.90	$a\ ^4G_{3\frac{1}{2}}-o\ ^2F^0_{3\frac{1}{2}}$						
50, IV	3249.517	30764.96	$a\ ^4F_{1\frac{1}{2}}-u\ ^4F^0_{1\frac{1}{2}}$	6	0.392	0.582	0.593	0.397	0.790
3	3247.645	30782.69	$a\ ^6D_{3\frac{1}{2}}-y\ ^6S^0_{2\frac{1}{2}}$						
15, V	3246.782	30790.87	$a\ ^4F_{1\frac{1}{2}}-w\ ^2F^0_{2\frac{1}{2}}$						
2	3244.684	30810.78	$a\ ^2G_{3\frac{1}{2}}-t\ ^2G^0_{3\frac{1}{2}}$						
1h	3244.20	30815.38	$a\ ^4G_{4\frac{1}{2}}-p\ ^4F^0_{4\frac{1}{2}}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	7	8	10
1	3243.723	30819.89	$b\ {}^4P_{3½}-p\ {}^2G]_{4½}$						
4	3243.322	30823.72	$a\ {}^4H_{3½}-q\ {}^4F]_{4½}$						
3	3242.928	30827.47							
1	3242.67	30829.92	$a\ {}^4H_{4½}-q\ {}^4F]_{4½}$						
1	3241.111	30844.75	$a\ {}^2D_{2½}-w\ {}^2P]_{2½}$						
3	3240.582	30849.78	$a\ {}^4F_{2½}-w\ {}^4D]_{3½}$						
2	3238.975	30865.09	$a\ {}^4F_{2½}-u\ {}^4F]_{3½}$						
3	3238.394	30870.63	$a\ {}^4F_{1½}-w\ {}^4F]_{2½}$ $a\ {}^4G_{2½}-o\ {}^2F]_{3½}$						
8	3237.187	30882.14	$a\ {}^4P_{1½}-u\ {}^4D]_{2½}$						
1	3236.810	30885.73	$a\ {}^4G_{3½}-p\ {}^4F]_{4½}$						
2	3236.704	30886.74	$a\ {}^4H_{4½}-q\ {}^4F]_{5½}$						
2	3236.078	30892.72	$a\ {}^2H_{3½}-p\ {}^4F]_{3½}$						
2	3235.182	30901.28	$a\ {}^4P_{2½}-s\ {}^2F]_{3½}$						
1	3235.066	30902.38	$a\ {}^6D_{1½}-x\ {}^4G]_{2½}$ $a\ {}^2D_{2½}-411]_{3½}$						
1	3234.65	30906.36	$a\ {}^4H_{3½}-p\ {}^2F]_{3½}$						
3	3232.984	30922.29	$a\ {}^4P_{2½}-u\ {}^4D]_{3½}$	6	2.592	1.296	1.296	2.592	0.000
2	3232.891	30923.18	$a\ {}^6D_{4½}-p\ {}^4F]_{4½}$ $a\ {}^4F_{1½}-w\ {}^4D]_{0½}$						
2h	3232.661	30925.37	$b\ {}^4D_{1½}-n\ {}^4D]_{½}$						
1	3231.336	30938.05	$a\ {}^4D_{2½}-r\ {}^4F]_{3½}$						
2	3230.794	30943.24	$a\ {}^4H_{4½}-p\ {}^2F]_{3½}$						
1	3230.53	30945.77	$a\ {}^4H_{5½}-r\ {}^2G]_{4½}$						
1	3229.455	30956.07	$a\ {}^2P_{2½}-w\ {}^2P]_{1½}$						
4	3229.19	30958.61	$a\ {}^4F_{3½}-w\ {}^4D]_{2½}$						
4	3227.711	30972.80	$a\ {}^4H_{3½}-s\ {}^2G]_{4½}$						
2h	3227.49	30974.92	$a\ {}^4G_{3½}-q\ {}^4D]_{3½}$						
9	3225.194	30996.97	$a\ {}^4F_{1½}-u\ {}^4F]_{2½}$						
2	3225.009	30998.74	$a\ {}^2P_{1½}-s\ {}^2D]_{2½}$						
8	3224.434	31004.27	$a\ {}^4G_{3½}-p\ {}^4F]_{3½}$						
3c	3223.751	31010.85							
1	3223.448	31013.76	$a\ {}^4P_{2½}-s\ {}^2F]_{3½}$						
3	3223.004	31018.03	$a\ {}^4P_{0½}-u\ {}^4D]_{1½}$						
6	3222.958	31018.47	$a\ {}^2G_{3½}-p\ {}^2H]_{4½}$						
7	3222.754	31020.44	$a\ {}^6D_{1½}-y\ {}^4S]_{½}$						
2	3221.436	31033.13	$a\ {}^2G_{4½}-r\ {}^4F]_{4½}$						
15, V	3221.126	31036.11	$a\ {}^4F_{2½}-x\ {}^2D]_{2½}$ $a\ {}^4G_{3½}-p\ {}^4F]_{3½}$	5		0	1.055	(1.029)	0.998
15, V	3220.927	31038.03	$a\ {}^4G_{4½}-p\ {}^4F]_{4½}$	6		0.27	1.20	(1.23)	1.17
6	3219.681	31050.04	$a\ {}^4G_{3½}-p\ {}^4D]_{3½}$						
6	3218.797	31058.57	$a\ {}^2G_{3½}-t\ {}^4G]_{4½}$						
20, V	3217.865	31067.57	$a\ {}^4F_{3½}-s\ {}^2F]_{3½}$	6		0.507	-----	(1.029)	0.829
30, V	3217.288	31073.13	$a\ {}^4P_{1½}-w\ {}^6S]_{½}$	6		0.42*	1.832	(1.721)	1.943
1	3215.959	31085.97	$b\ {}^4P_{1½}-m\ {}^2F]_{2½}$						
10, V	3215.229	31093.03	$a\ {}^2G_{4½}-t\ {}^4G]_{5½}$						
5	3213.884	31106.04	$a\ {}^4F_{1½}-w\ {}^4D]_{½}$						
1	3213.24	31112.28	$a\ {}^6D_{2½}-p\ {}^4F]_{3½}$ $b\ {}^4P_{2½}-r\ {}^4G]_{3½}$						
15, V	3210.29	31140.86	$a\ {}^2G_{4½}-q\ {}^2F]_{3½}$	4		0.172*	0.851	(1.103)	1.174
3	3208.86	31154.74	$a\ {}^4G_{3½}-p\ {}^4F]_{3½}$						
1h	3207.64	31166.59	$a\ {}^4D_{2½}-r\ {}^4F]_{2½}$						
5	3206.812	31174.64	$a\ {}^6D_{2½}-y\ {}^4S]_{½}$						
1	3206.11	31181.47	$a\ {}^2G_{3½}-s\ {}^4F]_{4½}$						
3	3205.975	31182.78	$a\ {}^2G_{3½}-400]_{3½}$						
2c	3204.66	31195.57	$a\ {}^4G_{3½}-q\ {}^4D]_{3½}$? $a\ {}^4G_{4½}-n\ {}^2F]_{3½}$						
4	3204.340	31198.69	$a\ {}^4F_{4½}-z\ {}^2H]_{5½}$						
4	3201.498	31226.39	$a\ {}^2G_{4½}-s\ {}^4G]_{5½}$	7b, 4		0	1.100	(1.103)	1.104
15, IV	3200.537	31235.76	$a\ {}^4F_{3½}-w\ {}^2D]_{2½}$	5		0	1.268	(1.235)	1.209
3c	3200.102	31240.01							
3	3198.182	31258.76	$a\ {}^4G_{3½}-p\ {}^4F]_{3½}$						
1h	3197.94	31261.12	$b\ {}^4D_{3½}-o\ {}^4F]_{3½}$						
5	3196.18	31278.34							
1	3194.64	31293.42	$a\ {}^2H_{4½}-p\ {}^4F]_{4½}$						
3	3194.367	31296.09	$a\ {}^2D_{1½}-q\ {}^2F]_{2½}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ_{air} A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
4c	3193.003	31309.46	$a\ ^6D_{3½}-z\ ^4G_{4½}$						
2	3192.73	31312.14	$a\ ^4F_{3½}-v\ ^2F_{3½}$						
3	3190.490	31334.12	$a\ ^2D_{2½}-s\ ^2G_{3½}$						
4	3189.560	31343.26							
40, IV	3187.497	31363.54	$a\ ^4F_{4½}-y\ ^4D_{3½}$	4		w	1.145	(1.330)	1.383
15, V	3186.550	31372.86	$a\ ^4P_{2½}-w\ ^4S_{1½}$	4	0.700	0.355	1.603	2.653	1.953
2	3185.55	31382.71	$a\ ^2G_{3½}-r\ ^4F_{3½}$						
1	3184.77	31390.39	$a\ ^2F_{3½}-o\ ^4D_{2½}$						
4c	3182.399	31413.78	$b\ ^2H_{4½}-o\ ^2G_{4½}$						
5	3182.063	31417.10	$a\ ^4F_{3½}-w\ ^4D_{3½}$						
1h	3181.11	31426.51	$a\ ^4D_{3½}-q\ ^2F_{3½}$						
2	3180.79	31429.67	$a\ ^4F_{4½}-w\ ^2G_{4½}$						
2	3178.632	31451.01	$a\ ^6D_{4½}-w\ ^4G_{3½}$						
1	3178.17	31455.58	$a\ ^4D_{3½}-s\ ^4D_{2½}$?						
3	3175.68	31480.24	$a\ ^4F_{3½}-x\ ^2D_{2½}$ $b\ ^4D_{1½}-4699_{2½}$						
4	3173.677	31500.11	$a\ ^4F_{2½}-w\ ^2D_{1½}$						
12, V	3172.511	31511.69	$a\ ^4F_{1½}-x\ ^2F_{2½}$	5	0.437	0.212	1.452	0.360	0.797
4	3172.304	31513.74	$a\ ^4F_{4½}-w\ ^2G_{3½}$						
10c	3171.425	31522.48	$a^6D_{4½}-z\ ^4G_{5½}$ $a^4G_{4½}-q\ ^2G_{3½}$						
6	3171.168	31525.03	$a\ ^2G_{4½}-r\ ^4F_{4½}$						
4	3170.163	31535.03	$a\ ^2G_{3½}-r\ ^4F_{3½}$						
8	3168.599	31550.60	$a\ ^2P_{2½}-r\ ^4D_{2½}$?			0	0.726		
2	3168.141	31555.15	$a\ ^6D_{4½}-s\ ^4F_{4½}$						
2h	3166.59	31570.60	$a\ ^2P_{1½}-o\ ^2F_{2½}$						
1h	3166.49	31571.60	$b\ ^4P_{2½}-r\ ^4G_{3½}$						
1	3166.230	31574.19	$a\ ^4P_{1½}-t\ ^4F_{1½}$						
2	3164.488	31591.57	$a\ ^2D_{2½}-p\ ^2F_{2½}$						
1	3164.148	31594.97	$a\ ^2F_{3½}-u\ ^2H_{4½}$ $a\ ^2G_{3½}-t\ ^4G_{4½}$						
1	3161.49	31621.53	$a\ ^6D_{3½}-w\ ^4F_{3½}$						
8	3161.194	31624.49	$a\ ^2G_{4½}-s\ ^4D_{3½}$						
3	3160.60	31630.44							
6	3159.332	31643.13	$a\ ^2D_{1½}-w\ ^2P_{1½}$	6	0.434	0.651	1.165	0.948	1.382
2h	3159.21	31644.35	$b\ ^4P_{2½}-o\ ^4F_{2½}$						
2	3158.962	31646.84	$a\ ^2G_{3½}-s\ ^4D_{2½}$						
2	3157.73	31659.18	$a\ ^4P_{2½}-x\ ^4H_{3½}$						
2	3154.321	31693.40	$a\ ^2D_{2½}-q\ ^4F_{2½}$						
10	3153.98	31696.82				0	0.97		
30, IV	3151.870	31718.04	$a\ ^4F_{2½}-s\ ^4D_{1½}$	4		...	0.998	(1.235)	1.330
6	3148.710	31749.87	$a\ ^2D_{2½}-p\ ^2F_{3½}$	4		0	0.976	(1.206)	1.140
2	3146.863	31768.51	$a\ ^4D_{1½}-s\ ^4D_{1½}$						
5	3145.920	31778.03	$a\ ^2H_{4½}-q\ ^2G_{4½}$						
1h	3144.45	31792.9	$b\ ^4P_{1½}-s\ ^2F_{2½}$						
1	3143.44	31803.1	$a\ ^4F_{3½}-w\ ^2D_{2½}$						
1h	3142.926	31808.30	$b\ ^4D_{2½}-n\ ^4D_{3½}$?						
2	3142.644	31811.16	$a\ ^2G_{4½}-4111_{3½}$						
2	3142.384	31813.79	$a\ ^4P_{1½}-t\ ^4F_{1½}$						
1	3138.888	31849.22	$a\ ^4P_{2½}-r\ ^2F_{3½}$						
15, V	3136.972	31868.67	$a\ ^4F_{1½}-s\ ^4D_{0½}$	4		0	0.381	(0.402)	0.444
1	3136.49	31873.6	$a\ ^6D_{4½}-w\ ^4F_{4½}$						
1	3134.835	31890.40	$a\ ^4P_{1½}-u\ ^4G_{1½}$						
2	3134.620	31892.58	$a\ ^2F_{3½}-m\ ^2F_{3½}$						
1	3133.89	31900.00	$a\ ^4P_{2½}-t\ ^2D_{2½}$						
15, V	3133.088	31908.18	$a\ ^2G_{3½}-q\ ^2F_{3½}$	4		0	0.833	(0.885)	0.927
1	3132.881	31910.28	$a^6D_{2½}-v\ ^4F_{1½}$ $a^4D_{2½}-s\ ^4D_{1½}$						
2	3132.589	31913.26	$b\ ^4P_{2½}-n\ ^4D_{2½}$						
2h	3131.61	31923.2	$b\ ^4F_{3½}-o\ ^4D_{2½}$						
4	3129.554	31944.21	$a\ ^4F_{1½}-w\ ^2D_{1½}$						
2	3125.197	31988.74	$a\ ^4P_{1½}-t\ ^4F_{1½}$						
3	3125.12	31989.5	$a\ ^4P_{2½}-t\ ^4D_{1½}$						
15, V	3122.646	32014.87	$a\ ^4F_{2½}-s\ ^4D_{2½}$	6	0.157	0.548	1.307	1.229	1.386

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm⁻¹	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
1h	3122.13	32020.2	$b\ ^4P_{3/2}-469\frac{1}{2}_{5/2}$						
5	3121.964	32021.86	$a\ ^2D_{1/2}-414\frac{1}{2}_{3/2}$	6	0.483	0.724	1.180	0.939	1.422
2h	3121.66	32024.98	$a\ ^2P_{1/2}-n\ ^2F_{3/2}$ $b\ ^4F_{3/2}-o\ ^4D_{3/2}$						
3h	3121.35	32028.2							
5	3120.878	32033.01	$a\ ^4F_{3/2}-z\ ^2H\frac{1}{2}_{5/2}$						
3	3120.276	32039.19	$a\ ^4D_{3/2}-w\ ^2P\frac{1}{2}_{3/2}$						
6	3119.402	32048.16	$a\ ^4F_{3/2}-y\ ^4G\frac{1}{2}_{5/2}$						
1	3117.65	32066.2	$a\ ^6D_{3/2}-w\ ^4D\frac{1}{2}_{3/2}$						
15, V	3116.366	32079.38	$a\ ^2D_{3/2}-z\ ^2D\frac{1}{2}_{3/2}$	4		0	1.194	(1.206)	1.214
1	3114.934	32094.13	$a\ ^2G_{3/2}-s\ ^4G\frac{1}{2}_{5/2}$						
1	3114.51	32098.5	$b\ ^4D_{1/2}-475\frac{1}{2}_{3/2}$						
2h	3114.38	32099.8	$a\ ^4H_{3/2}-p\ ^4F\frac{1}{2}_{3/2}$						
4	3113.061	32113.44	$a\ ^4P_{3/2}-t\ ^4F\frac{1}{2}_{3/2}$ $b\ ^4F_{3/2}-u\ ^2H\frac{1}{2}_{5/2}$						
3	3112.630	32117.89	$a\ ^4D_{3/2}-416\frac{1}{2}_{5/2}$						
2h	3112.08	32123.6	$b\ ^4P_{3/2}-o\ ^4F\frac{1}{2}_{3/2}$						
1	3111.79	32126.6	$a\ ^2G_{3/2}-s\ ^4D\frac{1}{2}_{3/2}$?						
2	3111.558	32128.95	$a\ ^4H_{3/2}-p\ ^4F\frac{1}{2}_{3/2}$						
20, V	3111.446	32130.11	$a\ ^4F_{3/2}-s\ ^4D\frac{1}{2}_{3/2}$	4	0.201	0.100	0.730	1.031	1.232
5	3109.735	32147.78	$a\ ^4H_{3/2}-p\ ^4F\frac{1}{2}_{3/2}$						
3	3108.07	32165.0	$a\ ^4F_{3/2}-w\ ^2G\frac{1}{2}_{5/2}$						
1	3105.79	32188.61	$b\ ^4F_{3/2}-o\ ^4D\frac{1}{2}_{3/2}$						
2h	3104.86	32198.26	$a\ ^2P_{3/2}-q\ ^4D\frac{1}{2}_{3/2}$						
1	3103.39	32213.5	$b\ ^4D_{3/2}-o\ ^4F\frac{1}{2}_{3/2}$ $b\ ^4F_{3/2}-o\ ^4D\frac{1}{2}_{3/2}$ $a\ ^2P_{3/2}-r\ ^4D\frac{1}{2}_{3/2}$						
1h	3101.69	32231.2	$a\ ^6D_{3/2}-x\ ^2D\frac{1}{2}_{3/2}$						
2	3101.064	32237.67	$a\ ^2D_{1/2}-r\ ^4D\frac{1}{2}_{3/2}$						
5	3100.97	32238.6	$a\ ^4P_{1/2}-t\ ^4D\frac{1}{2}_{3/2}$						
3	3100.163	32247.04	$a\ ^4F_{3/2}-w\ ^2D\frac{1}{2}_{3/2}$ $b\ ^4F_{3/2}-o\ ^4D\frac{1}{2}_{3/2}$						
2	3098.98	32259.4							
2	3098.780	32261.43	$a\ ^4F_{3/2}-z\ ^2H\frac{1}{2}_{5/2}$						
3h	3098.300	32266.43	$a\ ^4P_{3/2}-r\ ^2F\frac{1}{2}_{5/2}$						
10, V	3096.490	32285.29	$a\ ^4F_{3/2}-s\ ^4D\frac{1}{2}_{3/2}$	6	0.331	0.813	1.198	1.034	1.360
2	3095.22	32298.5	$b\ ^4P_{1/2}-n\ ^4F\frac{1}{2}_{3/2}$						
5	3094.37	32307.4	$a\ ^2D_{1/2}-q\ ^4F\frac{1}{2}_{3/2}$						
1	3093.65	32314.9	$b\ ^4F_{3/2}-m\ ^2F\frac{1}{2}_{5/2}$						
2	3090.13	32351.7	$a\ ^4F_{3/2}-s\ ^4G\frac{1}{2}_{5/2}$ $a\ ^4H_{3/2}-p\ ^4F\frac{1}{2}_{3/2}$						
9	3088.05	32373.5	$a\ ^4F_{3/2}-u\ ^2F\frac{1}{2}_{5/2}$						
1h	3087.75	32376.7	$b\ ^4P_{3/2}-n\ ^4D\frac{1}{2}_{3/2}$ $a\ ^4D_{1/2}-w\ ^2P\frac{1}{2}_{3/2}$						
4	3087.625	32377.98	$a\ ^6D_{1/2}-w\ ^4G\frac{1}{2}_{5/2}$						
2	3086.475	32390.04	$a\ ^2D_{1/2}-p\ ^2F\frac{1}{2}_{5/2}$						
1h	3085.67	32398.5	$b\ ^4D_{3/2}-o\ ^4F\frac{1}{2}_{3/2}$?						
4h	3084.94	32406.2							
2	3083.828	32417.85	$a\ ^4D_{3/2}-414\frac{1}{2}_{3/2}$						
1	3083.607	32420.17	$a\ ^4H_{3/2}-n\ ^2F\frac{1}{2}_{5/2}$						
10	3082.859	32428.03	$a\ ^4P_{3/2}-t\ ^4D\frac{1}{2}_{3/2}$						
3	3077.800	32481.33	$a\ ^4P_{3/2}-x\ ^2P\frac{1}{2}_{3/2}$						
3	3075.816	32502.28							
3	3074.447	32516.76	$a\ ^4P_{1/2}-r\ ^2F\frac{1}{2}_{5/2}$						
10	3072.397	32538.45	$a\ ^4P_{3/2}-t\ ^4D\frac{1}{2}_{3/2}$						
7	3072.296	32539.52	$a\ ^4F_{3/2}-y\ ^2H\frac{1}{2}_{5/2}$						
1	3071.77	32545.1	$a\ ^2G_{3/2}-q\ ^4F\frac{1}{2}_{3/2}$						
1	3071.34	32549.6	$a\ ^4F_{3/2}-x\ ^4P\frac{1}{2}_{3/2}$						
10	3069.023	32574.42	$a\ ^4F_{3/2}-p\ ^4D\frac{1}{2}_{3/2}$						
3	3066.41	32602.0	$a\ ^2G_{3/2}-q\ ^4F\frac{1}{2}_{3/2}$						
2	3061.78	32651.3	$a\ ^2D_{3/2}-o\ ^2F\frac{1}{2}_{3/2}$						
10	3061.232	32657.12	$a\ ^4P_{1/2}-t\ ^4D\frac{1}{2}_{3/2}$						
8	3061.100	32658.53	$a\ ^2G_{3/2}-p\ ^2F\frac{1}{2}_{5/2}$	4		0	1.057	(1.103)	1.129

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm⁻¹	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
5	3000.30	32666.1	$a\ ^4F_{3½}-y\ ^2P_{1½}$						
9	3056.608	32706.52				0.153	0.904		
1	3054.47	32729.4	$a\ ^4F_{1½}-s\ ^4D_{½}$						
3	3054.14	32733.0							
10	3053.086	32744.25	$a\ ^4F_{2½}-w\ ^4P_{1½}$	4		0.133h	1.497	(1.596)	1.662
6	3052.988	32745.30	$a\ ^2P_{1½}-s\ ^2P_{½}$	6		0	1.215	(1.175)	1.255
5	3052.73	32748.1							
8	3051.990	32756.01	$a\ ^2H_{3½}-u\ ^2H_{4½}$	6		0	1.08	(1.10)	1.06
6	3051.666	32759.48	$a\ ^4F_{1½}-y\ ^2P^0_{½}$	4		0	0.381	(0.402)	0.440
20	3048.093	32797.88	$a\ ^4P_{2½}-w\ ^4P_{2½}$	7b, 6		0	1.598	(1.596)	1.600
5	3045.546	32825.31	$a\ ^4F_{4½}-p\ ^4G_{5½}$						
5	3041.89	32864.8	$a\ ^2G_{4½}-r\ ^2G_{5½}$						
5	3041.660	32867.25	$a\ ^4P_{2½}-t\ ^2D_{2½}$						
5	3041.358	32870.51				0	0.900		
1	3040.67	32877.9	$a\ ^2D_{1½}-s\ ^2D_{2½}$						
3	3040.25	32882.5	$a\ ^4P_{1½}-t\ ^2D_{2½}$						
20	3039.68	32888.7	$a\ ^4P_{2½}-t\ ^4D_{3½}$						
7	3039.19	32894.0							
5	3033.396	32956.78	$a\ ^4P_{3½}-t\ ^4D_{4½}$						
3	3029.23	33002.1	$a\ ^2G_{3½}-p\ ^2F_{3½}$						
4	3029.17	33002.8	$a\ ^4F_{3½}-v\ ^4G_{4½}$						
7	3028.60	33008.0	$a\ ^2H_{4½}-u\ ^2H_{5½}$						
7	3027.80	33016.7	$a\ ^4P_{2½}-u\ ^2G_{3½}$						
1	3027.16	33024.7	$a\ ^4F_{3½}-u\ ^2F_{3½}$						
2	3023.38	33066.0	$a\ ^2F_{3½}-r\ ^4G_{4½}$						
20	3020.668	33095.65	$a\ ^4P_{1½}-t\ ^4D_{2½}$	4	0.389	0.146	0.804	1.777	1.388
3h	3019.780	33105.38	$a\ ^2D_{2½}-n\ ^2F_{3½}$						
2h	3019.34	33110.2	$a\ ^4F_{1½}-y\ ^2P^0_{½}$						
1	3016.258	33144.04	$a\ ^4D_{2½}-q\ ^4F_{1½}$						
8	3015.24	33155.2							
3h	3013.27	33176.9	$a^6D_{3½}-v\ ^4D_{3½}$ $a^6D_{3½}-p\ ^4D_{3½}$						
5	3012.546	33184.87	$a\ ^4P_{2½}-x\ ^2P^0_{½}$ $a^6D_{4½}-w\ ^2G_{4½}$	6		0	1.608	(2.650)	0.566
1	3007.284	33242.94	$a\ ^4F_{4½}-p\ ^2G_{4½}$						
3	3006.964	33246.46							
9	3005.141	33266.64	$a\ ^4F_{3½}-v\ ^4G_{3½}$	4		0	0.994	(1.029)	1.013
1	3004.49	33273.8	$a\ ^4D_{2½}-s\ ^2D_{2½}$						
4	3000.72	33315.6	$a\ ^2D_{2½}-n\ ^2F_{3½}$						
7h	3000.11	33322.4							
1	2998.312	33342.41	$a\ ^4F_{3½}-y\ ^2H_{4½}$						
5	2998.220	33343.43	$a\ ^4F_{3½}-s\ ^2D_{2½}$						
6h	2996.49	33362.7	$a\ ^2D_{1½}-p\ ^4D_{½}$						
5	2992.084	33411.80	$a\ ^4P_{1½}-w\ ^4P_{1½}$						
1	2989.63	33439.2	$a\ ^2F_{3½}-t\ ^2H_{4½}$						
6	2988.789	33448.64	$a\ ^4P_{2½}-x\ ^2P_{1½}$						
6	2988.692	33449.72	$a\ ^2D_{1½}-o\ ^2F_{2½}$						
15	2987.286	33465.47	$a\ ^4P_{1½}-w\ ^4P_{½}$	4		w	1.382	(1.721)	1.586
3h	2986.84	33470.5	$a\ ^4F_{4½}-x\ ^2H_{5½}$						
1	2986.02	33479.6	$a\ ^2H_{5½}-p\ ^2G_{5½}$						
4	2984.077	33501.47	$a\ ^4F_{1½}-x\ ^4P^0_{½}$						
5	2983.13	33512.1	$a\ ^4F_{1½}-v\ ^4G_{½}$						
15	2981.636	33528.88	$a\ ^4F_{4½}-u\ ^4D_{3½}$	4		0	1.227	(1.330)	1.389
1	2981.28	33532.9	$a\ ^4F_{3½}-x\ ^4S_{1½}$						
5	2974.54	33608.9							
1	2973.83	33616.9	$a\ ^2H_{4½}-p\ ^2G_{4½}$						
3	2972.47	33632.3							
1	2969.594	33664.84	$a\ ^4F_{1½}-y\ ^2S_{½}$						
10	2965.48	33711.5	$a\ ^4P_{2½}-w\ ^4P_{1½}$	4	0.946	0.462	1.186	2.605	1.659
5	2963.682	33731.99	$a\ ^4P_{2½}-w\ ^4P_{2½}$	6		0	2.601	(2.650)	2.552
1	2962.288	33747.86	$a^6D_{1½}-p\ ^4D_{½}$ $a^6D_{1½}-y\ ^2P^0_{½}$						
3	2959.973	33774.25	$a\ ^4F_{3½}-u\ ^2D_{2½}$	5		0	1.326	(1.235)	1.162

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ_{air} Å	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
5	2955.444	33826.01	$a\ ^3D_{3½}-p\ ^3P_{1½}$	4		0	1.079	(1.206)	1.291
2	2950.70	33880.4	$a\ ^3H_{4½}-p\ ^3G_{3½}$						
1*d*	2949.15	33898.2	$a\ ^4D_{3½}-p\ ^4F_{4½}$						
2	2948.060	33910.73	$a\ ^4F_{3½}-v\ ^3D_{2½}$						
6	2945.74	33937.4	$a\ ^4D_{1½}-q\ ^4D_{½}$ $a\ ^3P_{2½}-v\ ^3P_{1½}$						
1	2942.10	33979.4	$a\ ^4D_{3½}-p\ ^4F_{3½}$ $a\ ^3P_{1½}-m\ ^3F_{2½}$						
15	2938.067	34026.06	$a\ ^4F_{3½}-u\ ^4D_{2½}$	4		*ur*	1.084	(1.235)	1.296
5	2934.980	34061.85	$a\ ^3G_{3½}-o\ ^3F_{3½}$						
1h	2932.93	34085.6	$a\ ^3G_{4½}-p\ ^4D_{3½}$						
4	2929.662	34123.67	$a\ ^3F_{3½}-o\ ^3G_{3½}$						
2h	2929.13	34129.9	$a\ ^4D_{3½}-p\ ^4F_{4½}$ $b\ ^4F_{4½}-n\ ^4D_{3½}$						
8	2925.360	34173.85	$a\ ^4F_{4½}-s\ ^3F_{3½}$	5		--	1.958	(1.330)	1.151
10	2924.824	34180.11	$a\ ^4F_{3½}-u\ ^4D_{3½}$	6		--	1.306	(1.235)	1.377
8	2923.025	34201.15				0	1.180		
5	2916.500	34277.66							
1	2915.18	34293.2	$b\ ^4F_{3½}-n\ ^4D_{2½}$						
2	2915.059	34294.61	$a\ ^5D_{4½}-y\ ^3H_{5½}$						
2	2913.135	34317.26	$a\ ^4D_{1½}-p\ ^4F_{½}$						
2	2911.08	34341.5	$a\ ^4F_{2½}-u\ ^2D_{2½}$						
2	2910.69	34346.1	$a\ ^3G_{3½}-p\ ^4F_{4½}$?			0	1.16		
5	2908.88	34367.4				*w*	1.03		
3	2906.422	34396.52	$a\ ^4P_{2½}-r\ ^4F_{1½}$						
10	2903.650	34429.35	$a\ ^4F_{3½}-u\ ^4D_{1½}$	4		0h	0.799	(1.029)	1.182
1	2901.692	34452.58	$a\ ^4G_{2½}-r\ ^4G_{1½}$						
4	2897.605	34501.18							
6	2897.345	34504.27	$a\ ^4P_{2½}-q\ ^2F_{1½}$						
6	2896.998	34508.40	$a\ ^4P_{2½}-s\ ^4D_{½}$						
5h	2896.24	34517.4							
3	2894.90	34533.4							
1	2894.77	34534.9	$b\ ^4F_{4½}-o\ ^4F_{½}$						
3h	2893.47	34550.5							
6	2890.174	34589.87	$a\ ^4P_{2½}-s\ ^4G_{½}$						
10	2889.898	34593.18	$a\ ^4F_{2½}-u\ ^4D_{½}$						
6	2887.294	34624.38	$a\ ^2D_{1½}-p\ ^2P_{½}$						
12	2884.968	34652.29	$a\ ^2H_{2½}-t\ ^2H_{1½}$	6	0.101	0.450	1.049	(1.10)	1.00
1	2883.89	34665.2	$a\ ^3G_{4½}-o\ ^4F_{3½}$						
1	2883.626	34668.42	$a\ ^4G_{3½}-o\ ^4F_{½}$						
1	2879.97	34712.4	$a\ ^4F_{3½}-s\ ^3F_{2½}$						
8	2879.492	34718.19	$a\ ^4F_{4½}-u\ ^4G_{3½}$						
3	2878.818	34726.32	$a\ ^3G_{3½}-n\ ^2F_{2½}$						
3	2878.16	34734.3	$a\ ^4F_{4½}-t\ ^4F_{3½}$						
15	2874.564	34777.70	$a\ ^4F_{3½}-u\ ^4D_{2½}$	5	0.379	0.183	0.588	0.398	0.019
2h	2873.68	34788.4	$a\ ^4G_{4½}-n\ ^4F_{3½}$						
1h	2872.93	34797.5	$a\ ^4G_{4½}-t\ ^2H_{3½}$						
3	2871.238	34817.99							
5	2870.654	34825.07	$a\ ^4F_{3½}-s\ ^3F_{2½}$						
2	2868.96	34845.6	$b\ ^4F_{3½}-47_{2½}$						
8	2866.672	34873.44	$a\ ^4F_{1½}-u\ ^4D_{½}$ $a\ ^4F_{2½}-y\ ^4H_{3½}$	6	0.794	1.191 0.130	0.800 0.936	0.403	1.197
1	2862.49	34924.4	$a\ ^4F_{2½}-t\ ^3F_{1½}$?						
2	2861.76	34933.3	$a\ ^2D_{2½}-o\ ^4D_{½}$						
15	2859.962	34955.26	$a\ ^4F_{3½}-u\ ^4G_{3½}$						
10	2858.974	34967.34							
10	2857.294	34987.89	$a\ ^4P_{2½}-s\ ^4D_{½}$						
12	2854.168	35026.21	$a\ ^4F_{4½}-t\ ^4F_{3½}$	6	0.080	0.296	1.322*	(1.330)	1.320
3	2853.264	35037.31	$a\ ^4F_{3½}-u\ ^4D_{2½}$						
15	2851.978	35053.11	$a\ ^2H_{4½}-t\ ^2H_{3½}$ $a\ ^2G_{3½}-q\ ^2G_{3½}$	5		0h	1.28	(0.93)	0.99
20	2851.446	35059.65	$a\ ^2D_{2½}-m\ ^2F_{2½}$						
2	2845.52	35132.6	$a\ ^4F_{3½}-t\ ^4F_{2½}$						

TABLE 4.—*First spectrum of columbium* (Cb 1)—Continued

Intensity Arc	λ air A	Wave No. vac. cm⁻¹	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	7	8	10
6	2842.018	35175.95	a $^4P_{1½}$—s $^4D_{1½}$						
10	2840.929	35189.43	a $^4F_{1½}$—u $^4G_{1½}$						
10	2836.245	35247.54				0	1.03		
4	2833.648	35279.85	a $^4F_{1½}$—s $^2F_{1½}$						
3	2833.51	35281.6							
3	2829.367	35333.22							
3	2828.950	35338.43	a $^4F_{4½}$—x $^4H_{1½}$						
12	2826.47	35369.4	a $^4F_{1½}$—u $^4G_{1½}$						
10	2825.180	35385.58	a $^4F_{1½}$—t $^4F_{1½}$	6	0.064	0.190	1.170	(1.235)	1.171
4	2824.785	35390.53							
3	2824.642	35392.32	a $^4F_{1½}$—s $^2F_{1½}$						
8	2821.924	35426.41	[a $^4F_{4½}$—r $^2F_{1½}$						
			[a $^2H_{4½}$—o $^2G_{1½}$						
3	2820.38	35445.8	a $^4F_{4½}$—y $^2H_{1½}$						
15	2819.215	35460.45				w	1.39		
3	2818.74	35466.4	a $^2D_{1½}$—o $^4D_{1½}$						
2	2816.430	35495.51	a[$^4P_{2½}$—414]$_{1½}$						
1	2814.53	35519.5	a[$^4G_{3½}$—475]$_{1½}$						
6	2811.625	35556.17	a $^4H_{4½}$—r $^4G_{1½}$						
10	2808.050	35601.43	[a $^4F_{2½}$—u $^4G_{1½}$						
			[a $^2P_{1½}$—469]$_{1½}$						
7	2802.066	35677.46	a $^4F_{1½}$—t $^4F_{1½}$	5		0	1.288	(1.235)	1.254
10	2800.315	35699.77	a $^4F_{1½}$—t $^2F_{1½}$	6	0.067	0.145	1.006	1.040	0.973
7	2799.354	35712.03	a $^4F_{1½}$—x $^4H_{1½}$						
6	2798.428	35723.84	a $^4F_{1½}$—s $^2F_{1½}$						
3	2797.215	35739.33	a $^2H_{1½}$—o $^2G_{1½}$						
9	2795.868	35756.54	a $^4F_{2½}$—u $^4G_{1½}$	5		0	1.100	(1.029)	1.061
3	2793.973	35780.80	a $^4P_{1½}$—q $^4F_{1½}$						
3	2793.704	35784.24	a $^4P_{1½}$—w $^2P_{1½}$						
3	2789.200	35842.02	a $^2G_{4½}$—o $^4D_{1½}$						
½, Sn?	2787.944	35858.17	a $^2D_{1½}$—m $^2F_{1½}$						
4	2786.390	35878.17	a $^2P_{0½}$—p $^2P_{1½}$						
10	2782.356	35930.18	a $^2G_{4½}$—u $^2H_{1½}$	4		0	1.041	(1.103)	1.084
4	2780.600	35952.87	a $^4F_{1½}$—t $^4F_{1½}$						
10	2779.71	35964.4							
8	2779.36	35968.9	a $^4F_{1½}$—t $^4F_{1½}$	6	0.126	0.176	--	(0.402)	0.528
3	2774.935	36026.28	a $^4F_{1½}$—t $^2D_{1½}$						
3	2774.052	36037.73	a $^4F_{1½}$—x $^4H_{1½}$						
10	2773.197	36048.84	a $^4F_{4½}$—t $^4D_{1½}$	5		w	1.302	(1.330)	1.295
7	2766.182	36140.26	a $^2H_{4½}$—o $^2G_{1½}$						
5	2765.918	36143.71	a $^4F_{1½}$—t $^4F_{1½}$						
15	2763.380	36176.90	a $^4F_{4½}$—u $^2G_{1½}$	5		--	2.452	(1.330)	1.011
10	2760.990	36208.22							
2	2760.441	36215.42	a $^4F_{4½}$—w $^2H_{1½}$						
10r	2758.005	36239.52	a $^4F_{1½}$—t $^4D_{1½}$	4		--	1.046+	(1.235)	1.386
10	2755.632	36278.61	a $^4F_{2½}$—t $^2D_{1½}$						
20	2755.288	36283.15	a $^2G_{3½}$—u $^2H_{1½}$						
3	2754.40	36294.8	a $^4F_{1½}$—w $^2H_{1½}$						
6	2754.066	36299.24							
10	2753.007	36313.20				0	1.145		
3	2752.682	36317.49	a $^4P_{1½}$—416]$_{1½}$						
10r	2748.848	36368.14	a $^4F_{2½}$—t $^4D_{1½}$	4		0	1.011	(1.029)	1.053
10r	2746.910	36393.80	a $^4F_{1½}$—t $^4D_{2½}$	5	0.287	0.146	0.553	0.409	0.122
1	2742.79	36448.5	a $^4P_{1½}$—q $^4F_{1½}$						
2	2741.71	36462.8	a $^4P_{0½}$—414]$_{1½}$						
10	2741.146	36470.33	a $^2G_{3½}$—m $^2F_{1½}$						
2	2734.027	36565.29	a $^2D_{1½}$—p $^2P_{1½}$						
6	2729.829	36621.51	a $^4F_{3½}$—t $^2G_{1½}$						
6	2728.076	36645.05	a $^4F_{2½}$—r $^2F_{1½}$						
6	2726.080	36671.86	a $^4F_{1½}$—r $^2F_{1½}$						
2	2725.68	36677.3	a $^4P_{1½}$—q $^4D_{1½}$						
2	2725.33	36682.0	a $^2D_{1½}$—469]$_{1½}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ_{air} A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	7	8	10
15	2723.986	36700.06	a $^4F_{3½}$—t $^4D^0_{3½}$	6		w	1.277	(1.235)	1.319
6	2722.310	36722.65	a $^4F_{1½}$—t $^2D^0_{1½}$						
5	2720.024	36753.51	a $^4P_{2½}$—r $^4D^0_{3½}$						
15	2716.100	36806.61	a $^4F_{2½}$—t $^4D^0_{2½}$						
8	2715.690	36812.16	a $^4F_{1½}$—t $^4D^0_{1½}$						
6	2715.500	36814.74	a $^4F_{4½}$—z $^4F^0_{4½}$						
5	2714.198	36832.40	a $^4F_{3½}$—t $^2G^0_{4½}$						
2	2712.17	36859.9	a $^4F_{2½}$—x $^2F^0_{2½}$						
4	2698.965	37040.27	a^{5}F$_{1½}$—x $^2F^0_{2½}$ a^{4}F$_{4½}$—e $^2H^0_{4½}$						
3	2698.540	37046.09	a $^4D_{2½}$—o $^4F^0_{2½}$						
8	2696.052	37080.28	a $^4F_{4½}$—t $^4G^0_{5½}$						
30	2695.038	37094.24	a $^4F_{1½}$—s $^4F^0_{1½}$	5		--	1.857	(1.235)	0.986
2	2689.182	37175.02	a $^4F_{1½}$—q $^4D^0_{1½}$?						
30r	2687.149	37203.13	a $^4F_{4½}$—s $^4F^0_{4½}$	6	0.205	0.922	--	(1.330)	1.125
4	2683.713	37250.76	a $^4F_{1½}$—t $^4D^0_{1½}$						
1	2682.524	37267.27	a $^4F_{2½}$—t $^4D^0_{2½}$						
10	2682.129	37272.76	a $^4F_{3½}$—t $^2G^0_{3½}$						
6	2679.880	37304.03	a $^4F_{1½}$—x $^2F^0_{1½}$						
20	2679.015	37316.08	a $^4F_{3½}$—s $^4F^0_{3½}$	5	0.503	0.292	1.922	1.032	0.439
1	2678.30	37326.0	a $^4P_{2½}$—q $^4D^0_{2½}$						
3	2676.952	37344.84	a $^4P_{1½}$—q $^4D^0_{1½}$						
4	2674.694	37376.36	a $^4F_{3½}$—t $^4G^0_{3½}$						
2	2673.332	37395.40	a $^4F_{2½}$—u $^2G^0_{3½}$ a^{2}G$_{4½}$—r $^4G^0_{5½}$						
2c	2671.447	37421.78	a $^4D_{3½}$—46$0^0_{3½}$						
5	2670.524	37434.72	a $^4D_{2½}$—n $^4F^0_{2½}$						
1	2669.512	37448.91	a $^4P_{2½}$—p $^4D^0_{3½}$						
40r	2668.283	37466.16	a $^4F_{3½}$—s $^4F^0_{3½}$	6	0.138	0.484	1.132*	(1.235)	1.097
8	2661.852	37556.67	a $^4F_{4½}$—r $^4F^0_{4½}$						
3	2661.124	37566.95	a $^4F_{1½}$—w $^4F^0_{1½}$						
40r	2657.613	37616.57	a $^4F_{5½}$—t $^4G^0_{5½}$	6	0.108	0.402	--	(1.330)	1.222
10	2656.984	37625.48	a $^2G_{4½}$—t $^2H^0_{5½}$	6		0	1.04	(1.10)	0.98
8	2655.695	37643.74	a $^2G_{3½}$—r $^4G^0_{4½}$						
60R	2654.446	37661.45	a $^4F_{2½}$—s $^4F^0_{2½}$	6		0	0.996	(1.029)	0.964
2	2654.242	37664.34	a $^4F_{4½}$—q $^2F^0_{3½}$						
6	2653.476	37675.22							
10	2653.372	37676.69	a $^4F_{4½}$—t $^4G^0_{4½}$						
8	2652.944	37682.77	a $^2G_{3½}$—n $^4F^0_{3½}$						
2	2652.335	37691.42	a $^4F_{3½}$—o $^2H^0_{4½}$						
3	2650.568	37716.55	a $^2G_{3½}$—o $^4F^0_{3½}$						
1	2650.001	37724.62	a $^4P_{1½}$—p $^4F^0_{1½}$						
50r	2649.515	37731.54	a $^4F_{5½}$—t $^4G^0_{4½}$	6	0.155	0.459	1.142	1.219	1.064
3	2648.223	37749.94	a $^4F_{4½}$—s $^4G^0_{4½}$						
80R	2647.500	37760.25	a $^4F_{1½}$—s $^4F^0_{1½}$	6		0	0.424	(0.401)	0.447
2c	2644.449	37803.81	a $^4D_{4½}$—t $^4D^0_{3½}$						
1	2642.87	37826.4	a $^2G_{4½}$—t $^2H^0_{4½}$						
4	2641.923	37839.96	a^{4}D$_{2½}$—r $^2F^0_{2½}$ a^{4}F$_{3½}$—t $^2G^0_{3½}$						
20	2640.918	37854.36	a $^4F_{3½}$—s $^4F^0_{3½}$	4		0A	0.869	(1.235)	1.102
2	2640.825	37855.69	a $^4F_{3½}$—40$0^0_{3½}$						
1	2639.39	37876.3	a $^4D_{3½}$—46$0^0_{3½}$						
1	2635.985	37925.15	a $^4F_{3½}$—s $^4G^0_{3½}$						
1	2635.512	37932.00	a $^4D_{4½}$—u $^2G^0_{3½}$						
10	2634.704	37943.63	a $^4F_{1½}$—t $^4G^0_{2½}$	6		--	0.815	(1.029)	0.601
1	2634.493	37946.67	a $^2G_{4½}$—n^{4}D$^0_{3½}$						
2	2633.981	37954.05	a $^4D_{3½}$—n^{4}D$^0_{2½}$						
20	2628.493	38033.28	a $^4F_{3½}$—s $^4F^0_{1½}$	5		0	1.182	(1.029)	1.097
60	2627.435	38048.60	a $^4F_{4½}$—r $^4F^0_{5½}$	6	0.073	0.269	1.253	1.330	1.257
3	2626.472	38062.55							
25	2623.507	38105.56	a $^4F_{1½}$—s $^4F^0_{2½}$						
4	2622.804	38115.78	a $^4F_{4½}$—s $^4G^0_{4½}$						
7	2622.003	38127.42	a $^2G_{3½}$—t $^2H^0_{4½}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm⁻¹	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
8	2020.585	38148.05	a $^4F_{3/2}$–s $^4D_{1/2}$						
1c	2018.178	38183.12	a $^4D_{3/2}$–o $^4F_{1/2}$						
4	2017.046	38199.63	a $^2G_{4/2}$–o $^2G_{3/2}$						
10	2616.476	38207.95	a $^4F_{3/2}$–r $^4F_{3/2}$	6	0.109	0.322	1.182	1.236	1.127
3	2614.444	38237.65							
15	2612.377	38267.90	a $^4F_{3/2}$–t $^4G_{1/2}$	7b, 4		0	1.220	(1.235)	1.230
1	2612.028	38273.01	a $^2F_{3/2}$–n $^2G_{1/2}$						
20	2610.268	38298.82	a $^4F_{3/2}$–t $^4G_{3/2}$	5		0	1.229	(1.029)	1.086
1	2609.118	38315.70	a $^4F_{3/2}$–q $^2F_{3/2}$						
6	2608.836	38319.84	a $^4F_{3/2}$–s $^4D_{3/2}$						
1	2604.225	38387.68	a $^4F_{3/2}$–t $^4G_{5/2}$						
6	2603.306	38401.23	a $^4F_{3/2}$–s $^4G_{3/2}$						
8	2602.011	38420.34							
7	2601.832	38422.98	a $^4F_{3/2}$–$4002_{3/2}$						
3	2601.597	38426.45							
10	2597.138	38492.43	a $^4F_{3/2}$–s $^4G_{5/2}$	6		--	0.979	(1.029)	0.929
4	2594.685	38528.81							
4	2592.911	38555.17							
50	2592.190	38565.89	a $^4F_{5/2}$–s $^4G_{5/2}$	4		0	0.982	(1.330)	1.267
5	2589.264	38609.47							
1	2588.36	38622.9	a $^4F_{3/2}$–r $^4F_{1/2}$						
8	2583.219	38699.82	a $^4F_{3/2}$–r $^4F_{3/2}$						
15	2583.103	38701.56	a $^2G_{3/2}$–o $^2G_{1/2}$	6		--	0.898	(0.885)	0.911
7	2581.194	38730.18	a $^2D_{3/2}$–w $^2F_{1/2}$						
50	2578.734	38767.12	a $^4F_{3/2}$–s $^4G_{1/2}$	7b, 5		0	1.244	(1.235)	1.238
8	2578.203	38775.10	a $^4F_{3/2}$–r $^4F_{5/2}$						
4	2578.086	38776.87							
7	2576.592	38799.35	a $^4F_{3/2}$–s $^4D_{1/2}$						
1	2572.80	38856.5	a $^4D_{3/2}$–s $^4F_{1/2}$?						
15	2572.099	38867.12	a $^4F_{3/2}$–$4002_{1/2}$						
7	2571.054	38882.91	a $^4F_{3/2}$–q $^2F_{1/2}$						
6	2570.782	38887.03	a $^4F_{3/2}$–s $^4D_{3/2}$						
20	2569.030	38913.55	a $^2G_{4/2}$–o $^2G_{3/2}$	7b, 6		0	1.104	(1.103)	1.105
20	2567.510	38936.58	a $^4F_{1/2}$–s $^4G_{3/2}$	5	0.513	--	1.689	0.407	0.920
3	2567.281	38940.05	a $^4P_{3/2}$–o $^4D_{3/2}$						
10	2565.410	38968.45	a $^4F_{3/2}$–s $^4G_{3/2}$	5		0	1.216	(1.029)	1.082
8	2564.735	38978.71							
4	2564.265	38985.85	a $^4F_{3/2}$–$4111_{3/2}$						
1	2559.05	39065.29	a $^4P_{5/2}$–p $^2F_{3/2}$						
20	2558.936	39067.03	a $^4F_{3/2}$–r $^4F_{3/2}$	5	0.508	0.258	1.634	0.364	0.872
2	2558.835	39068.57	a $^4F_{5/2}$–q $^4F_{3/2}$						
4	2557.41	39090.3	a $^4F_{5/2}$–s $^2G_{3/2}$						
3	2555.107	39125.57	a $^4F_{3/2}$–q $^4F_{1/2}$						
12	2554.103	39140.95							
3	2553.752	39146.33							
2	2550.878	39190.43	a $^4D_{3/2}$–t $^4G_{1/2}$						
7	2549.904	39205.40	a $^4P_{3/2}$–o $^4D_{1/2}$						
2	2544.723	39285.22	a $^2H_{3/2}$–n $^2G_{1/2}$						
10	2543.980	39296.69							
3	2543.252	39307.94							
1	2542.925	39313.00	a $^4D_{3/2}$–s $^4F_{3/2}$?						
5	2541.972	39327.73							
2	2541.704	39331.88	a $^4P_{3/2}$–m $^2F_{3/2}$						
1	2539.464	39366.57	a $^4F_{3/2}$–s $^4D_{3/2}$						
1	2539.128	39371.78	a $^4D_{3/2}$–t $^4G_{3/2}$						
6	2538.055	39388.42	a $^4F_{5/2}$–r $^2G_{3/2}$						
1	2535.259	39431.86	a $^4D_{3/2}$–t $^4G_{3/2}$						
4	2527.277	39556.39							
10	2524.985	39592.29	a $^4F_{1/2}$–q $^2F_{3/2}$ a $^4F_{3/2}$–q $^4F_{3/2}$	5		--	1.296	(0.402)	0.760
7	2524.006	39607.65	a $^4F_{3/2}$–o $^4D_{3/2}$						
3	2521.924	39640.34							
2	2521.880	39641.04	a $^4P_{3/2}$–o $^4D_{3/2}$						
10	2520.507	39662.63							
2	2519.018	39686.07	a $^2H_{3/2}$–n $^2G_{3/2}$						
1	2516.878	39719.81	a $^4F_{3/2}$–q $^4F_{3/2}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	φ1	φ2
1	2	3	4	5	6	7	8	9	10
4	2515.775	39737.22							
3	2514.784	39752.88							
1	2514.750	39753.42	a $^4P_{3/2}$—p $^3G_{5/2}$?						
2	2513.273	39776.78	a $^4F_{3/2}$—q $^4F_{3/2}$						
3	2511.573	39803.70	a $^6D_{3/2}$—r $^4F_{3/2}$						
6	2507.134	39874.17	a $^4F_{3/2}$—414$j_{5/2}$						
30	2504.648	39913.74	a $^4F_{3/2}$—r $^4D_{3/2}$	4		w	1.12	(1.33)	1.39
4	2502.944	39940.91	a $^4P_{3/2}$—o $^4D_{5/2}$						
2	2499.282	39999.43	a $^4P_{1/2}$—m $^2F_{5/2}$						
2	2497.464	40028.55	a $^4F_{3/2}$—416$j_{5/2}$						
3	2494.801	40071.27							
2	2489.112	40162.85	a $^4F_{3/2}$—s $^2D_{5/2}$						
1	2479.351	40320.95	a $^6D_{3/2}$—s $^4G_{5/2}$						
8	2476.478	40367.73	a $^4F_{3/2}$—p $^4F_{5/2}$						
15	2474.655	40397.47	a $^4F_{3/2}$—r $^4D_{5/2}$	4		0	0.698	(1.235)	1.450
2	2473.752	40412.21	a $^4F_{1/2}$—q $^4F_{3/2}$						
25	2469.072	40488.80	a $^4F_{3/2}$—q $^4D_{5/2}$						
1	2468.064	40505.34	a $^4P_{3/2}$—r $^4G_{5/2}$						
3	2467.630	40512.46							
20	2466.727	40527.29	a $^4F_{3/2}$—q $^4D_{3/2}$						
10	2466.318	40534.02	a $^4F_{1/2}$—r $^4D_{5/2}$						
2	2465.709	40544.02	a $^4P_{3/2}$—n $^4F_{3/2}$						
10	2464.432	40565.03	a $^4F_{3/2}$—r $^4D_{3/2}$						
5	2463.631	40578.22	a $^4P_{3/2}$—o $^4F_{3/2}$						
20	2462.889	40590.44	a $^4F_{3/2}$—p $^4F_{3/2}$	6		--	1.259	(1.330)	1.188
10	2461.757	40609.11	a $^4F_{3/2}$—p $^4D_{3/2}$						
5	2458.575	40661.66							
1	2456.83	40690.5	a $^6D_{3/2}$—w $^2P_{1/2}$?						
3	2455.872	40706.41	a $^4P_{1/2}$—p $^2P_{3/2}$						
2	2454.163	40734.75	a $^4F_{3/2}$—o $^4F_{3/2}$						
20	2453.367	40747.97	{a $^6D_{3/2}$—411$j_{3/2}$ {a $^4F_{3/2}$—n $^2F_{5/2}$						
20	2453.084	40752.67	a $^4F_{3/2}$—r $^4D_{1/2}$						
4	2447.413	40847.09	a $^4P_{3/2}$—s $^4D_{3/2}$						
10	2446.130	40868.51	a $^4F_{3/2}$—p $^4F_{3/2}$						
1	2445.913	40872.14	a $^4P_{3/2}$—o $^4F_{3/2}$						
20	2445.066	40886.30	a $^4F_{3/2}$—q $^4D_{3/2}$						
8	2443.529	40912.01							
2	2441.021	40954.04	a $^4P_{3/2}$—469$j_{5/2}$						
5	2440.392	40964.60	a $^4F_{3/2}$—r $^4D_{3/2}$						
3	2439.715	40975.97							
2	2439.445	40980.50	a $^4P_{5/2}$—n $^4D_{5/2}$						
3	2437.924	41006.07	a $^4P_{5/2}$—s $^2P_{3/2}$						
9	2437.161	41018.90	a $^4F_{3/2}$—p $^4F_{5/2}$						
10	2436.329	41032.90	a $^4F_{3/2}$—p $^4D_{5/2}$						
6	2434.962	41055.95	a $^4F_{3/2}$—q $^4D_{5/2}$						
4	2434.878	41057.36	a $^4P_{3/2}$—o $^4F_{5/2}$						
1	2434.310	41066.94	a $^4P_{1/2}$—n $^4D_{1/2}$						
10	2433.680	41077.59							
2	2430.442	41132.29	a $^4F_{3/2}$—r $^4D_{5/2}$						
3	2428.848	41159.28							
3	2428.096	41172.03	a $^4P_{5/2}$—o $^4F_{5/2}$						
3	2428.047	41172.86							
1	2427.714	41178.51	a $^4F_{3/2}$—q $^4D_{5/2}$						
9	2427.536	41181.52	a $^4F_{3/2}$—q $^4D_{3/2}$						
3	2427.105	41188.84	a $^4F_{3/2}$—n $^2F_{5/2}$						
5	2426.957	41191.35							
6A	2426.637	41196.78	a $^4F_{3/2}$—r $^4D_{5/2}$						
5	2425.741	41212.00	a $^4P_{1/2}$—n $^4F_{3/2}$						
4	2423.996	41241.66	a $^4F_{3/2}$—p $^4F_{3/2}$						
3	2422.900	41260.32	a $^4F_{3/2}$—p $^4D_{3/2}$						
2	2420.461	41301.89	a $^4F_{3/2}$—o $^2F_{5/2}$						

TABLE 4.—*First spectrum of columbium* (Cb 1)—Continued

Intensity Arc	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
7	2420.144	41307.30	$a\,{}^4F_{3\frac{1}{2}}-p\,{}^4F_{1\frac{1}{2}}$						
5c	2419.976	41310.16	$a\,{}^4P_{3\frac{1}{2}}-n\,{}^4D_{3\frac{1}{2}}$						
6	2419.804	41313.10	$a\,{}^4F_{3\frac{1}{2}}-p\,{}^4D_{1\frac{1}{2}}$						
4	2418.792	41330.38	$a\,{}^4F_{1\frac{1}{2}}-q\,{}^4D_{1\frac{1}{2}}$						
3	2418.490	41335.55							
2c	2414.762	41399.35	$a\,{}^4F_{3\frac{1}{2}}-n\,{}^2F_{3\frac{1}{2}}$						
7	2414.206	41408.89	$a\,{}^4F_{1\frac{1}{2}}-r\,{}^4D_{1\frac{1}{2}}$						
5	2412.645	41435.68	$a\,{}^4F_{2\frac{1}{2}}-p\,{}^4F_{2\frac{1}{2}}$						
3h	2410.792	41467.53							
2	2408.056	41514.64	$a\,{}^4P_{1\frac{1}{2}}-n\,{}^4D_{2\frac{1}{2}}$						
10	2406.942	41533.85							
4	2403.918	41586.09	$a\,{}^4F_{2\frac{1}{2}}-p\,{}^4F_{2\frac{1}{2}}$						
4	2403.107	41600.12	$a\,{}^4F_{2\frac{1}{2}}-p\,{}^4D_{2\frac{1}{2}}$						
8c	2402.339	41613.42							
3	2401.873	41621.49	$a\,{}^6D_{3\frac{1}{2}}-s\,{}^3D_{3\frac{1}{2}}$ $a\,{}^4P_{1\frac{1}{2}}-4692_{3\frac{1}{2}}$						
5	2400.910	41638.19							
5	2399.718	41658.87	$a\,{}^4F_{1\frac{1}{2}}-p\,{}^4D_{0\frac{1}{2}}$						
2	2395.851	41726.10	$a\,{}^4F_{2\frac{1}{2}}-q\,{}^2G_{3\frac{1}{2}}$						
4	2394.395	41751.47	$a\,{}^4F_{1\frac{1}{2}}-p\,{}^4F_{1\frac{1}{2}}$						
5	2394.058	41757.35	$a\,{}^4F_{1\frac{1}{2}}-p\,{}^4D_{1\frac{1}{2}}$						
4	2390.454	41820.30							
4	2382.246	41964.38							
3	2373.074	42126.56							
15	2368.860	42201.49							
3	2368.64	42205.41							
1	2366.715	42239.74	$a\,{}^4P_{1\frac{1}{2}}-4751_{1\frac{1}{2}}$						
3	2365.940	42253.57							
5h	2364.325	42282.43	$a\,{}^6D_{4\frac{1}{2}}-q\,{}^4D_{3\frac{1}{2}}$						
4h	2363.852	42290.89	$a\,{}^4D_{3\frac{1}{2}}-n\,{}^2G_{4\frac{1}{2}}$						
2	2363.716	42293.32	$a\,{}^4F_{2\frac{1}{2}}-q\,{}^2G_{3\frac{1}{2}}$						
4	2363.062	42305.03	$a\,{}^4F_{4\frac{1}{2}}-u\,{}^2H_{5\frac{1}{2}}$						
3	2362.50	42315.1							
2	2360.794	42345.67	$a\,{}^6D_{4\frac{1}{2}}-p\,{}^4F_{3\frac{1}{2}}$						
3	2359.679	42365.67	$a\,{}^4F_{4\frac{1}{2}}-o\,{}^4D_{3\frac{1}{2}}$						
5	2358.134	42393.43							
2	2357.910	42397.46	$a\,{}^6D_{1\frac{1}{2}}-r\,{}^4D_{2\frac{1}{2}}$						
9	2354.470	42459.39	$a\,{}^3G_{4\frac{1}{2}}-n\,{}^3G_{5\frac{1}{2}}$						
10	2353.80	42471.5							
6	2353.510	42476.71	$a\,{}^4F_{2\frac{1}{2}}-s\,{}^2P_{1\frac{1}{2}}$						
3	2352.131	42501.61							
2	2352.055	42502.99	$a\,{}^6D_{4\frac{1}{2}}-n\,{}^2F_{3\frac{1}{2}}$						
4	2351.677	42509.82							
6	2350.034	42539.54	$a\,{}^4P_{0\frac{1}{2}}-4751_{1\frac{1}{2}}$						
10c	2348.756	42562.68							
10c	2347.171	42591.42							
10c	2346.679	42600.34							
8c	2344.640	42637.39	$a\,{}^6D_{2\frac{1}{2}}-q\,{}^4D_{1\frac{1}{2}}$						
15c	2344.517	42639.63							
3	2341.152	42700.92	$a\,{}^6D_{2\frac{1}{2}}-p\,{}^4F_{1\frac{1}{2}}$?						
10	2340.277	42716.87							
8	2340.149	42719.21	$a\,{}^6D_{3\frac{1}{2}}-p\,{}^4D_{2\frac{1}{2}}$						
4	2338.730	42745.12							
2	2338.38	42751.5	$a\,{}^4F_{1\frac{1}{2}}-o\,{}^4D_{2\frac{1}{2}}$						
20c	2337.744	42763.16							
7	2336.410	42787.57							
10	2333.650	42838.16							
2	2329.543	42913.68	$a\,{}^4F_{4\frac{1}{2}}-p\,{}^2G_{3\frac{1}{2}}$						
5	2328.222	42938.03							
4	2328.077	42940.70	$a\,{}^6D_{3\frac{1}{2}}-q\,{}^4D_{2\frac{1}{2}}$						
3	2326.964	42961.24	$a\,{}^3G_{3\frac{1}{2}}-n\,{}^3G_{4\frac{1}{2}}$						
4	2324.600	43004.93							
1	2323.959	43016.79	$a\,{}^4F_{1\frac{1}{2}}-o\,{}^4D_{1\frac{1}{2}}$						
3	2323.654	43022.43	$a\,{}^6D_{2\frac{1}{2}}-p\,{}^4D_{1\frac{1}{2}}$						
8	2322.992	43034.69							
4	2321.489	43062.54							

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm^{-1}	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	8	9	10
5	2318.432	43119.33							
5	2316.271	43159.55							
4	2314.359	43195.21							
7	2311.676	43245.33							
3	2307.759	43318.72	$a\ ^4F_{3½}-o\ ^4D_{3½}$						
4	2305.975	43252.24	$a\ ^4F_{2½}-o\ ^4D_{1½}$						
3	2305.29	43365.12							
8	2300.854	43448.72							
6	2300.295	43459.27							
6	2293.274	43592.32							
5h	2289.840	43657.68							
5h	2287.504	43702.26							
4h	2283.377	43781.24							
1	2280.912	43828.55	$a\ ^4F_{1½}-p\ ^2G_{1½}$						
2	2279.414	43857.35	$a\ ^4F_{2½}-r\ ^4G_{2½}$						
15	2277.426	43895.63							
4c	2276.223	43918.83	$a\ ^4F_{4½}-r\ ^4G_{4½}$						
9c	2274.770	43946.88							
4	2269.653	44045.95							
4	2269.535	44048.24							
3	2268.59	44066.6							
2	2265.489	44126.89	$a\ ^4F_{4½}-n\ ^4F_{5½}$						
4	2265.217	44132.19	$a\ ^4F_{3½}-p\ ^2G_{3½}$						
3	2264.354	44149.01	$a\ ^4F_{4½}-t\ ^2H_{5½}$						
20	2260.854	44217.35	$a\ ^4F_{3½}-o\ ^4F_{3½}$						
100	2257.886	44275.47	$a\ ^4F_{4½}-r\ ^4G_{5½}$						
6	2256.075	44311.01							
5	2255.791	44316.59	$a\ ^4F_{2½}-r\ ^4G_{1½}$						
150	2254.564	44340.70	$a\ ^4F_{3½}-n\ ^4F_{4½}$						
8	2253.802	44355.69	$a\ ^4F_{2½}-n\ ^4F_{3½}$						
2	2252.09	44389.4	$a\ ^4F_{2½}-o\ ^4F_{2½}$						
4c	2252.51	44400.8							
100c	2250.308	44424.56	$a\ ^4F_{2½}-r\ ^4G_{2½}$						
80	2247.907	44470.22	$a\ ^4F_{4½}-n\ ^4D_{3½}$						
8c	2246.421	44501.42							
90c	2246.176	44506.26							
20	2242.958	44570.11	$a\ ^4F_{2½}-r\ ^4G_{3½}$						
20	2242.294	44583.31	$a\ ^4F_{1½}-o\ ^4F_{1½}$						
8h	2241.855	44592.04							
80c	2238.518	44658.51	$a\ ^4F_{2½}-n\ ^4D_{2½}$						
10	2236.22	44704.40							
9	2233.172	44765.40	$a\ ^4F_{2½}-469½_{4½}$						
80c	2232.845	44777.97	$a\ ^4F_{2½}-n\ ^4F_{2½}$ $a\ ^4F_{2½}-n\ ^4D_{1½}$						
8	2231.428	44800.39	$a\ ^4F_{1½}-t\ ^2H_{1½}$						
30	2229.65	44836.11	$a\ ^4F_{1½}-n\ ^4D_{2½}$						
4	2228.39	44861.46	$a\ ^4F_{1½}-s\ ^2P_{2½}$						
100c	2228.032	44868.69	$a\ ^4F_{1½}-r\ ^4G_{2½}$ $a\ ^4F_{1½}-o\ ^4F_{1½}$						
150c	2227.706	44875.23	$a\ ^4F_{4½}-o\ ^4F_{4½}$						
10	2227.280	44883.82	$a\ ^4F_{3½}-r\ ^4G_{3½}$						
15	2226.927	44890.93							
80	2225.343	44922.88	$a\ ^4F_{2½}-n\ ^4F_{3½}$						
6	2225.235	44925.06							
60c	2223.672	44956.62	$a\ ^4F_{2½}-o\ ^4F_{2½}$						
70c	2220.184	45027.25	$a\ ^4F_{1½}-o\ ^4F_{1½}$						
3	2218.357	45064.33							
15	2217.872	45074.19							
30c	2215.54	45121.6	$a\ ^4F_{2½}-n\ ^4D_{3½}$						
40c	2214.034	45152.31							
50c	2211.46	45204.9							
7	2210.622	45222.00	$a\ ^4F_{1½}-n\ ^4D_{1½}$						
6	2210.442	45225.68	$a\ ^4F_{2½}-n\ ^4D_{2½}$						

TABLE 4.—*First spectrum of columbium* (Cb I)—Continued

Intensity Arc	λ air A	Wave No. vac. cm⁻¹	Term combination	Zeeman type	Separation	Strongest p	Strongest n	g_1	g_2
1	2	3	4	5	6	7	7	8	10
2	2205.230	45332.56	$a\,^4F_{3/2}-4691_{5/2}$						
12	2204.617	45345.16	$a\,^4F_{3/2}-n\,^4F_{3/2}$						
3	2203.555	45367.01	$a\,^4F_{1/2}-n\,^4F_{3/2}$						
3	2201.916	45400.78	$a\,^4F_{1/2}-o\,^4F_{3/2}$						
4	2200.218	45435.81	$a\,^4F_{3/2}-o\,^4F_{1/2}$						
3	2195.83	45526.6	$a\,^4F_{3/2}-o\,^4F_{1/2}$						
10	2193.805	45568.61							
8	2193.011	45585.11							
7	2188.944	45669.80	$a\,^4F_{1/2}-n\,^4D_{3/2}$						
4	2178.225	45894.51							
3	2178.07	45897.8							
6	2175.555	45950.83	$a\,^4F_{3/2}-475l_{5/2}$						
5	2166.77	46137.1							
5	2161.54	46248.7							

Of particular interest is the large number of intersystem transitions, doublet-quartet combinations being second in abundance only to quartet-quartet. As in V I [7] doublet-sextet combinations appear in Cb I, but more abundantly. These latter include the transition $a\,^4D-z\,^2G°$, a conspicuous five-line multiplet, all lines of which show fully resolved Zeeman patterns. The wavelengths are 3867.918, 3815.507, 3803.879, 3771.848, and 3753.171 A. See figures 1 and 2.

TABLE 5.—*Distribution of classified* Cb I *lines*

Item	Number	Percentage of total number	Percentage of total intensity
		Percent	*Percent*
Lines in table 4	3,313		
Classified lines	2,836	85.6	93.4
Level transitions	3,035		
Sextet-sextet transitions	137	4.5	
Quartet-quartet transitions	1,276	42.1	
Doublet-doublet transitions	405	13.3	
Quartet-sextet transitions	253	8.3	
Doublet-quartet transitions	814	26.8	
Doublet-sextet transitions	57	1.9	
Transitions involving one unassigned level	92	3.0	
Lines classified two ways	191		
Lines classified three ways	3		
Zeeman patterns measured	911		
Zeeman patterns interpreted	815	89.5	

2. TERMS OF THE Cb I SPECTRUM

The established terms of Cb I, or energy states of neutral columbium, are described in table 6, which is prepared according to the same plan as table 2 for Cb II. All level values are relative to $4d^4\,5s\,a\,^6D_{0\frac{1}{2}}=0.00$. The total number of levels is 364, comprising 103 belonging to 58 doublets, 197 which make up 55 quartets, 56 which are associated with 13 sextets, and 8 unassigned levels. Levels associated with almost all terms come in regular order, that is, those of highest j-value are highest. There are five inverted doublets and five partially inverted quartets. Fifteen terms are incomplete. Instances of

good agreement with the interval rule are in the minority. This is t
be expected in the spectrum of an atom with a moderately heav
nucleus with level separations large enough that most terms overlap
a situation which leads to mutual perturbation and displacement o
levels of the same j-value associated with sharing of g-values
Attention is called to a few noteworthy instances of such perturbation
Levels $a\ ^2P_{1½}$ and $a\ ^2D_{1½}$ have g-values 1.175 and 0.953 as compared
with Landé g's, 1.333 and 0.800, respectively. The sums are almost
identical, 2.128 and 2.133. Levels $a\ ^2P_{0½}$ and $a\ ^2D_{2½}$ have nearly
Landé g-values. The levels of j-values 2½, 3½, and 4½ belonging t
$a\ ^4G$ and $b\ ^4F$ perturb one another to such an extent that it is difficul
to distinguish between them on the basis of combinations or g-value
although there is no doubt that these levels comprise the terms i
question. The levels $b\ ^4F_{1½}$ and $a\ ^4G_{5½}$ being unique values are not s
affected and again show nearly Landé g's. A very marked perturba-
tion occurs in the levels $x\ ^6D^\circ_{0½}$ and $y\ ^4D^\circ_{0½}$, the g-values being 2.44
and 1.141, respectively instead of 3.333 and 0.000 theoretically
expected. It may be assumed that these levels originate in the sam
electron configuration. Hence $x\ ^6D$ is assigned to $d^4\,p$ instead o
$d^3\,sp$, interchanging the assignment with $y\ ^6D^\circ$, as given in th
earlier paper [5]. The term formerly classified $z\ ^4D^\circ$ is now designate
$z\ ^6F^\circ$, with an additional level, $j=4½$, found, but with the level o
highest j missing. The g-values favor the new assignment, and ther
is no other possibility for this sextet, which is expected to show
strong combinations. These are almost the only instances of change
in earlier assignments. In using the scheme of designating inter-
mediate odd terms in ascending order by letters beginning with z
the discovery of a large number of new terms has necessitated
reassignment of such letters for identification. Relative level value
as set up in the earlier publication have been retained. Calculation
based on additional wavelength data indicate negligible corrections.

TABLE 6.—*Terms of the* Cb I *spectrum*

Electron configuration	Term symbol	Level	Difference	Observed g	Combinations
$d^4s\,(^5D)$	$a\ ^6D_{0½}$	0.00		3.323	$z\ ^8S^\circ$, $z\ ^6P^\circ$, $y\ ^6P^\circ$, $z\ ^6D^\circ$, $y\ ^6D^\circ$, $x\ ^6D^\circ$, $z\ ^6F^\circ$, $y\ ^6F^\circ$, $z\ ^4S^\circ$, $y\ ^4S^\circ$, $z\ ^4P^\circ$, $y\ ^4P^\circ$, $w\ ^4P^\circ$, $z\ ^4D^\circ$, $y\ ^4D^\circ$, $z\ ^4D^\circ$, $w\ ^4D^\circ$, $p\ ^4D^\circ$, $t\ ^4D^\circ$, $r\ ^4D^\circ$, $q\ ^4D^\circ$, $p\ ^4D^\circ$, $z\ ^4F^\circ$, $y\ ^4F^\circ$, $z\ ^4F^\circ$, $w\ ^4F^\circ$, $p\ ^4F^\circ$, $s\ ^4F^\circ$, $r\ ^4F^\circ$, $p\ ^4F^\circ$, $z\ ^4G^\circ$, $y\ ^4G^\circ$, $x\ ^4G^\circ$, $w\ ^4G^\circ$, $p\ ^4G^\circ$, $t\ ^4G^\circ$, $s\ ^4G^\circ$, $z\ ^4H^\circ$, $z\ ^2S^\circ$, $z\ ^2P^\circ$, $y\ ^2P^\circ$, $z\ ^2D^\circ$, $y\ ^2D^\circ$, $z\ ^2D^\circ$, $s\ ^2D^\circ$, $z\ ^2F^\circ$, $r\ ^2F^\circ$, $z\ ^2G^\circ$, $y\ ^2G^\circ$, $w\ ^2G^\circ$, $y\ ^2H^\circ$ 214°, 276°, 411°.
	$a\ ^6D_{1½}$	154.19	154.19	1.863	
	$a\ ^6D_{2½}$	391.99	237.80	1.652	
	$a\ ^6D_{3½}$	695.25	303.26	1.582	
	$a\ ^6D_{4½}$	1050.26	355.01	1.549	
d^3s^2	$a\ ^4F_{1½}$	1142.79		0.402	$z\ ^6S^\circ$, $y\ ^6S^\circ$, $z\ ^6S^\circ$, $z\ ^4P^\circ$, $y\ ^4P^\circ$, $z\ ^4P^\circ$, $w\ ^4P^\circ$, $z\ ^4D^\circ$, $y\ ^4D^\circ$, $z\ ^4D^\circ$, $w\ ^4D^\circ$, $s\ ^4D^\circ$, $t\ ^4D^\circ$, $s\ ^4D^\circ$, $r\ ^4D^\circ$, $q\ ^4D^\circ$, $p\ ^4D^\circ$, $o\ ^4D^\circ$, $n\ ^4D^\circ$, $z\ ^4F^\circ$, $y\ ^4F^\circ$, $z\ ^4F^\circ$, $w\ ^4F^\circ$, $s\ ^4F^\circ$, $u\ ^4F^\circ$, $t\ ^4F^\circ$, $s\ ^4F^\circ$, $r\ ^4F^\circ$, $q\ ^4F^\circ$, $p\ ^4F^\circ$, $p\ ^4F^\circ$, $n\ ^4F^\circ$, $z\ ^4G^\circ$, $y\ ^4G^\circ$, $z\ ^4G^\circ$, $w\ ^4G^\circ$, $s\ ^4G^\circ$, $u\ ^4G^\circ$, $t\ ^4G^\circ$, $s\ ^4G^\circ$, $z\ ^4H^\circ$, $y\ ^4H^\circ$, $z\ ^4H^\circ$, $z\ ^2S^\circ$, $z\ ^2P^\circ$, $y\ ^2P^\circ$, $z\ ^2P^\circ$, $w\ ^2P^\circ$, $s\ ^2P^\circ$, $z\ ^2D^\circ$, $y\ ^2D^\circ$, $z\ ^2D^\circ$, $w\ ^2D^\circ$, $s\ ^2D^\circ$, $u\ ^2D^\circ$, $t\ ^2D^\circ$, $s\ ^2D^\circ$, $z\ ^2F^\circ$, $y\ ^2F^\circ$, $w\ ^2F^\circ$, $s\ ^2F^\circ$, $u\ ^2F^\circ$, $t\ ^2F^\circ$, $s\ ^2F^\circ$, $r\ ^2F^\circ$, $q\ ^2F^\circ$, $o\ ^2F^\circ$, $n\ ^2F^\circ$, $z\ ^2G^\circ$, $y\ ^2G^\circ$, $x\ ^2G^\circ$, $w\ ^2G^\circ$, $s\ ^2G^\circ$, $u\ ^2G^\circ$, $t\ ^2G^\circ$, $s\ ^2G^\circ$, $r\ ^2G^\circ$, $p\ ^2G^\circ$, $z\ ^2H^\circ$, $y\ ^2H^\circ$, $z\ ^2H^\circ$, $w\ ^2H^\circ$, $s\ ^2H^\circ$, $t\ ^2H^\circ$, $z\ ^2I^\circ$, $y\ ^2I^\circ$ 214°, 276° 400°, 411°, 414°, 416°, 469°, 475°.
	$a\ ^4F_{2½}$	1586.90	444.11	1.029	
	$a\ ^4F_{3½}$	2154.11	567.21	1.235	
	$a\ ^4F_{4½}$	2805.36	651.25	1.330	

TABLE 6.—*Terms of the* Cb I *spectrum*—Continued

Electron configuration	Term symbol	Level	Difference	Observed g	Combinations
d^3p^3	$a\ {}^4P_{5/2}$	4908.17	299.75	2.650	$z\ {}^4S^\circ$, $y\ {}^4S^\circ$, $x\ {}^4S^\circ$, $w\ {}^4S^\circ$, $z\ {}^4P^\circ$, $y\ {}^4P^\circ$, $x\ {}^4P^\circ$, $w\ {}^4P^\circ$, $x\ {}^4D^\circ$, $y\ {}^4D^\circ$, $x\ {}^4D^\circ$, $w\ {}^4D^\circ$, $v\ {}^4D^\circ$, $u\ {}^4D^\circ$, $t\ {}^4D^\circ$, $s\ {}^4D^\circ$, $r\ {}^4D^\circ$, $q\ {}^4D^\circ$, $p\ {}^4D^\circ$, $o\ {}^4D^\circ$, $n\ {}^4D^\circ$, $m\ {}^4D^\circ$, $z\ {}^4F^\circ$, $y\ {}^4F^\circ$, $x\ {}^4F^\circ$, $w\ {}^4F^\circ$, $v\ {}^4F^\circ$, $u\ {}^4F^\circ$, $t\ {}^4F^\circ$, $r\ {}^4F^\circ$, $q\ {}^4F^\circ$, $p\ {}^4F^\circ$, $o\ {}^4F^\circ$, $n\ {}^4F^\circ$, $y\ {}^4G^\circ$, $w\ {}^4G^\circ$, $v\ {}^4G^\circ$, $u\ {}^4G^\circ$, $s\ {}^4G^\circ$, $r\ {}^4G^\circ$, $z\ {}^4H^\circ$, $y\ {}^4H^\circ$, $x\ {}^4H^\circ$, $z\ {}^2S^\circ$, $y\ {}^2S^\circ$, $z\ {}^2P^\circ$, $y\ {}^2P^\circ$, $x\ {}^2P^\circ$, $w\ {}^2P^\circ$, $v\ {}^2P^\circ$, $z\ {}^2D^\circ$, $y\ {}^2D^\circ$, $x\ {}^2D^\circ$, $w\ {}^2D^\circ$, $v\ {}^2D^\circ$, $u\ {}^2D^\circ$, $t\ {}^2D^\circ$, $z\ {}^2F^\circ$, $y\ {}^2F^\circ$, $w\ {}^2F^\circ$, $v\ {}^2F^\circ$, $u\ {}^2F^\circ$, $r\ {}^2F^\circ$, $q\ {}^2F^\circ$, $m\ {}^2F^\circ$, $z\ {}^2G^\circ$, $y\ {}^2G^\circ$, $x\ {}^2G^\circ$, $w\ {}^2G^\circ$, $u\ {}^2G^\circ$, 411°, 414°, 416°, 469°, 475°.
	$a\ {}^4D_{5/2}$	8410.90		0.06	
$d^3s\ ({}^4D)$	$a\ {}^4D_{3/2}$	8705.32	294.42	1.197	$x\ {}^4S^\circ$, $z\ {}^4P^\circ$, $y\ {}^4P^\circ$, $x\ {}^4P^\circ$, $w\ {}^4P^\circ$, $z\ {}^4D^\circ$, $y\ {}^4D^\circ$, $x\ {}^4D^\circ$, $w\ {}^4D^\circ$, $v\ {}^4D^\circ$, $u\ {}^4D^\circ$, $t\ {}^4D^\circ$, $s\ {}^4D^\circ$, $z\ {}^4F^\circ$, $y\ {}^4F^\circ$, $x\ {}^4F^\circ$, $w\ {}^4F^\circ$, $v\ {}^4F^\circ$, $u\ {}^4F^\circ$, $t\ {}^4F^\circ$, $s\ {}^4F^\circ$, $r\ {}^4F^\circ$, $q\ {}^4F^\circ$, $p\ {}^4F^\circ$, $o\ {}^4F^\circ$, $n\ {}^4F^\circ$, $z\ {}^4G^\circ$, $y\ {}^4G^\circ$, $x\ {}^4G^\circ$, $w\ {}^4G^\circ$, $v\ {}^4G^\circ$, $u\ {}^4G^\circ$, $z\ {}^4H^\circ$, $z\ {}^4P^\circ$, $y\ {}^4P^\circ$, $z\ {}^4D^\circ$, $y\ {}^4D^\circ$, $x\ {}^4D^\circ$, $w\ {}^4D^\circ$, $v\ {}^4D^\circ$, $u\ {}^4D^\circ$, $t\ {}^4D^\circ$, $s\ {}^4D^\circ$, $r\ {}^4D^\circ$, $q\ {}^4D^\circ$, $p\ {}^4D^\circ$, $o\ {}^4D^\circ$, $n\ {}^4D^\circ$, $z\ {}^4F^\circ$, $y\ {}^4F^\circ$, $x\ {}^4F^\circ$, $w\ {}^4F^\circ$, $v\ {}^4F^\circ$, $u\ {}^4F^\circ$, $t\ {}^4F^\circ$, $s\ {}^4F^\circ$, $r\ {}^4F^\circ$, $q\ {}^4F^\circ$, $p\ {}^4F^\circ$, $o\ {}^4F^\circ$, $n\ {}^4F^\circ$, $z\ {}^4G^\circ$, $y\ {}^4G^\circ$, $x\ {}^4G^\circ$, $w\ {}^4G^\circ$, $v\ {}^4G^\circ$, $u\ {}^4G^\circ$, $z\ {}^4H^\circ$, $z\ {}^4P^\circ$, $y\ {}^4P^\circ$, $z\ {}^4D^\circ$, $y\ {}^4D^\circ$, $x\ {}^4D^\circ$, $z\ {}^4F^\circ$, $y\ {}^4F^\circ$, $x\ {}^4F^\circ$, $w\ {}^4F^\circ$, $v\ {}^4F^\circ$, $u\ {}^4F^\circ$, $t\ {}^4F^\circ$, $s\ {}^4F^\circ$, $r\ {}^4F^\circ$, $q\ {}^4F^\circ$, $p\ {}^4F^\circ$, $o\ {}^4F^\circ$, $n\ {}^4F^\circ$, $z\ {}^4G^\circ$, $y\ {}^4G^\circ$, $x\ {}^4G^\circ$, $w\ {}^4G^\circ$, $v\ {}^4G^\circ$, $u\ {}^4G^\circ$, $t\ {}^4G^\circ$, $z\ {}^4G^\circ$, $r\ {}^4G^\circ$, $z\ {}^4H^\circ$, $y\ {}^4H^\circ$, $x\ {}^4H^\circ$, $z\ {}^2I^\circ$, $y\ {}^2I^\circ$, $z\ {}^2P^\circ$, $y\ {}^2P^\circ$, $x\ {}^2P^\circ$, $w\ {}^2P^\circ$, $z\ {}^2D^\circ$, $y\ {}^2D^\circ$, $x\ {}^2D^\circ$, $w\ {}^2D^\circ$, $v\ {}^2D^\circ$, $u\ {}^2D^\circ$, $t\ {}^2D^\circ$, $s\ {}^2D^\circ$, $y\ {}^2F^\circ$, $x\ {}^2F^\circ$, $w\ {}^2F^\circ$, $v\ {}^2F^\circ$, $u\ {}^2F^\circ$, $q\ {}^2F^\circ$, $z\ {}^2G^\circ$, $y\ {}^2G^\circ$, $x\ {}^2G^\circ$, $w\ {}^2G^\circ$, $u\ {}^2G^\circ$, $w\ {}^2H^\circ$, 276°, 414°, 416°, 469°.
	$a\ {}^3G_{5/2}$	8827.00		0.885	
d^3s^2	$a\ {}^3G_{3/2}$	9328.88	501.88	1.103	$y\ {}^3D^\circ$, $v\ {}^3D^\circ$, $u\ {}^3D^\circ$, $z\ {}^3F^\circ$, $y\ {}^3F^\circ$, $x\ {}^3F^\circ$, $w\ {}^3F^\circ$, $v\ {}^3F^\circ$, $u\ {}^3F^\circ$, $t\ {}^3F^\circ$, $s\ {}^3F^\circ$, $r\ {}^3F^\circ$, $q\ {}^3F^\circ$, $p\ {}^3F^\circ$, $o\ {}^3F^\circ$, $m\ {}^3F^\circ$, $z\ {}^3G^\circ$, $y\ {}^3G^\circ$, $x\ {}^3G^\circ$, $w\ {}^3G^\circ$, $v\ {}^3G^\circ$, $u\ {}^3G^\circ$, $t\ {}^3G^\circ$, $r\ {}^3G^\circ$, $q\ {}^3G^\circ$, $o\ {}^3G^\circ$, $n\ {}^3G^\circ$, $z\ {}^3H^\circ$, $y\ {}^3H^\circ$, $x\ {}^3H^\circ$, $w\ {}^3H^\circ$, $v\ {}^3H^\circ$, $u\ {}^3H^\circ$, $t\ {}^3H^\circ$, $z\ {}^1I^\circ$, $y\ {}^1I^\circ$, $z\ {}^4P^\circ$, $z\ {}^4D^\circ$, $y\ {}^4D^\circ$, $x\ {}^4D^\circ$, $w\ {}^4D^\circ$, $v\ {}^4D^\circ$, $t\ {}^4D^\circ$, $s\ {}^4D^\circ$, $n\ {}^4D^\circ$, $z\ {}^4F^\circ$, $y\ {}^4F^\circ$, $x\ {}^4F^\circ$, $w\ {}^4F^\circ$, $v\ {}^4F^\circ$, $u\ {}^4F^\circ$, $t\ {}^4F^\circ$, $s\ {}^4F^\circ$, $r\ {}^4F^\circ$, $q\ {}^4F^\circ$, $p\ {}^4F^\circ$, $o\ {}^4F^\circ$, $n\ {}^4F^\circ$, $z\ {}^4G^\circ$, $y\ {}^4G^\circ$, $x\ {}^4G^\circ$, $w\ {}^4G^\circ$, $v\ {}^4G^\circ$, $u\ {}^4G^\circ$, $t\ {}^4G^\circ$, $z\ {}^4G^\circ$, $r\ {}^4G^\circ$, $z\ {}^4H^\circ$, $y\ {}^4H^\circ$, $x\ {}^4H^\circ$, $z\ {}^4I^\circ$, $y\ {}^4D^\circ$, $z\ {}^4F^\circ$, 276°, 400°, 411°.
	$a\ {}^2D_{3/2}$	9439.08		0.953	
d^3p^3	$a\ {}^2D_{5/2}$	10237.51	798.43	1.206	$z\ {}^2S^\circ$, $y\ {}^2S^\circ$, $z\ {}^2P^\circ$, $y\ {}^2P^\circ$, $x\ {}^2P^\circ$, $w\ {}^2P^\circ$, $v\ {}^2P^\circ$, $z\ {}^2D^\circ$, $y\ {}^2D^\circ$, $x\ {}^2D^\circ$, $w\ {}^2D^\circ$, $v\ {}^2D^\circ$, $u\ {}^2D^\circ$, $t\ {}^2D^\circ$, $y\ {}^2F^\circ$, $x\ {}^2F^\circ$, $w\ {}^2F^\circ$, $v\ {}^2F^\circ$, $u\ {}^2F^\circ$, $s\ {}^2F^\circ$, $r\ {}^2F^\circ$, $q\ {}^2F^\circ$, $p\ {}^2F^\circ$, $o\ {}^2F^\circ$, $n\ {}^2F^\circ$, $m\ {}^2F^\circ$, $v\ {}^2G^\circ$, $u\ {}^2G^\circ$, $s\ {}^2G^\circ$, $z\ {}^4S^\circ$, $y\ {}^4S^\circ$, $x\ {}^4S^\circ$, $w\ {}^4S^\circ$, $z\ {}^4P^\circ$, $y\ {}^4P^\circ$, $x\ {}^4P^\circ$, $w\ {}^4P^\circ$, $y\ {}^4D^\circ$, $x\ {}^4D^\circ$, $w\ {}^4D^\circ$, $v\ {}^4D^\circ$, $u\ {}^4D^\circ$, $t\ {}^4D^\circ$, $s\ {}^4D^\circ$, $p\ {}^4D^\circ$, $o\ {}^4D^\circ$, $z\ {}^4F^\circ$, $w\ {}^4F^\circ$, $v\ {}^4F^\circ$, $u\ {}^4F^\circ$, $t\ {}^4F^\circ$, $s\ {}^4F^\circ$, $q\ {}^4F^\circ$, $z\ {}^4G^\circ$, $w\ {}^4G^\circ$, $v\ {}^4G^\circ$, $u\ {}^4G^\circ$, $t\ {}^4G^\circ$, $s\ {}^4G^\circ$, $z\ {}^4H^\circ$, $z\ {}^2S^\circ$, $y\ {}^2P^\circ$, $z\ {}^2D^\circ$, 276°, 411°, 414°, 469°.
	$a\ {}^2P_{3/2}$	10126.06		0.66	
d^3p^2	$a\ {}^2P_{1/2}$	11318.09	1192.03	1.175	$z\ {}^2S^\circ$, $z\ {}^2P^\circ$, $y\ {}^2P^\circ$, $x\ {}^2P^\circ$, $w\ {}^2P^\circ$, $v\ {}^2P^\circ$, $z\ {}^2D^\circ$, $y\ {}^2D^\circ$, $x\ {}^2D^\circ$, $w\ {}^2D^\circ$, $v\ {}^2D^\circ$, $u\ {}^2D^\circ$, $t\ {}^2D^\circ$, $s\ {}^2D^\circ$, $y\ {}^2F^\circ$, $w\ {}^2F^\circ$, $v\ {}^2F^\circ$, $u\ {}^2F^\circ$, $s\ {}^2F^\circ$, $p\ {}^2F^\circ$, $o\ {}^2F^\circ$, $n\ {}^2F^\circ$, $m\ {}^2F^\circ$, $z\ {}^4S^\circ$, $z\ {}^4P^\circ$, $y\ {}^4P^\circ$, $x\ {}^4P^\circ$, $w\ {}^4P^\circ$, $y\ {}^4D^\circ$, $x\ {}^4D^\circ$, $w\ {}^4D^\circ$, $u\ {}^4D^\circ$, $t\ {}^4D^\circ$, $r\ {}^4D^\circ$, $z\ {}^4F^\circ$, $y\ {}^4F^\circ$, $w\ {}^4F^\circ$, $v\ {}^4F^\circ$, $u\ {}^4F^\circ$, $t\ {}^4F^\circ$, $r\ {}^4F^\circ$, $q\ {}^4F^\circ$, $v\ {}^4G^\circ$, $u\ {}^4G^\circ$, $t\ {}^4G^\circ$, $z\ {}^4S^\circ$, $y\ {}^4P^\circ$, $z\ {}^4D^\circ$, $y\ {}^4F^\circ$, 469°.
d^5	$a\ {}^6S_{5/2}$	11344.70		1.99	$z\ {}^6P^\circ$, $y\ {}^6P^\circ$, $y\ {}^6F^\circ$, $z\ {}^6S^\circ$, $y\ {}^6P^\circ$, $w\ {}^6P^\circ$, $v\ {}^6P^\circ$, $v\ {}^6D^\circ$, $w\ {}^6D^\circ$, $x\ {}^6G^\circ$, $z\ {}^5P^\circ$, $x\ {}^5P^\circ$, $y\ {}^5D^\circ$, $v\ {}^5F^\circ$.
	$a\ {}^4H_{13/2}$	10922.74		0.690	
$d^4s\ ({}^5H)$	$a\ {}^4H_{11/2}$	11044.08	121.34	0.984	$u\ {}^4D^\circ$, $t\ {}^4D^\circ$, $s\ {}^4D^\circ$, $z\ {}^4F^\circ$, $y\ {}^4F^\circ$, $x\ {}^4F^\circ$, $w\ {}^4F^\circ$, $v\ {}^4F^\circ$, $u\ {}^4F^\circ$, $t\ {}^4F^\circ$, $s\ {}^4F^\circ$, $r\ {}^4F^\circ$, $q\ {}^4F^\circ$, $p\ {}^4F^\circ$, $z\ {}^4G^\circ$, $y\ {}^4G^\circ$, $x\ {}^4G^\circ$, $w\ {}^4G^\circ$, $v\ {}^4G^\circ$, $u\ {}^4G^\circ$, $t\ {}^4G^\circ$, $s\ {}^4G^\circ$, $r\ {}^4G^\circ$, $z\ {}^4H^\circ$, $y\ {}^4H^\circ$, $x\ {}^4H^\circ$, $z\ {}^4I^\circ$, $z\ {}^2D^\circ$, $z\ {}^2F^\circ$, $w\ {}^2F^\circ$, $v\ {}^2F^\circ$, $u\ {}^2F^\circ$, $s\ {}^2F^\circ$, $r\ {}^2F^\circ$, $p\ {}^2F^\circ$, $n\ {}^2F^\circ$, $w\ {}^2G^\circ$, $v\ {}^2G^\circ$, $u\ {}^2G^\circ$, $t\ {}^2G^\circ$, $s\ {}^2G^\circ$, $r\ {}^2G^\circ$, $z\ {}^2H^\circ$, $y\ {}^2H^\circ$, $x\ {}^2H^\circ$, $w\ {}^2H^\circ$, $v\ {}^2H^\circ$, $z\ {}^2I^\circ$, $y\ {}^2I^\circ$, 400°, 416°.
	$a\ {}^4H_{15/2}$	11247.83	276.77	1.12	
	$a\ {}^4H_{17/2}$	11524.65		1.22	
	$a\ {}^4G_{5/2}$	12018.25		0.742	
$d^4s\ ({}^5G)$	$a\ {}^4G_{7/2}$	12136.86	118.61	1.081	$z\ {}^4P^\circ$, $z\ {}^4D^\circ$, $y\ {}^4D^\circ$, $x\ {}^4D^\circ$, $w\ {}^4D^\circ$, $v\ {}^4D^\circ$, $u\ {}^4D^\circ$, $t\ {}^4D^\circ$, $q\ {}^4D^\circ$, $p\ {}^4D^\circ$, $z\ {}^4F^\circ$, $y\ {}^4F^\circ$, $x\ {}^4F^\circ$, $w\ {}^4F^\circ$, $v\ {}^4F^\circ$, $u\ {}^4F^\circ$, $t\ {}^4F^\circ$, $s\ {}^4F^\circ$, $r\ {}^4F^\circ$, $q\ {}^4F^\circ$, $p\ {}^4F^\circ$, $o\ {}^4F^\circ$, $n\ {}^4F^\circ$, $z\ {}^4G^\circ$, $y\ {}^4G^\circ$, $x\ {}^4G^\circ$, $w\ {}^4G^\circ$, $v\ {}^4G^\circ$, $u\ {}^4G^\circ$, $t\ {}^4G^\circ$, $s\ {}^4G^\circ$, $r\ {}^4G^\circ$, $z\ {}^4H^\circ$, $y\ {}^4H^\circ$, $x\ {}^4H^\circ$, $z\ {}^4I^\circ$, $y\ {}^4D^\circ$, $x\ {}^2P^\circ$, $w\ {}^2P^\circ$, $z\ {}^2D^\circ$, $y\ {}^2D^\circ$, $x\ {}^2D^\circ$, $w\ {}^2D^\circ$, $v\ {}^2D^\circ$, $u\ {}^2D^\circ$, $z\ {}^2F^\circ$, $y\ {}^2F^\circ$, $w\ {}^2F^\circ$, $v\ {}^2F^\circ$, $u\ {}^2F^\circ$, $s\ {}^2F^\circ$, $r\ {}^2F^\circ$, $q\ {}^2F^\circ$, $p\ {}^2F^\circ$, $o\ {}^2F^\circ$, $z\ {}^2G^\circ$, $y\ {}^2G^\circ$, $w\ {}^2G^\circ$, $v\ {}^2G^\circ$, $u\ {}^2G^\circ$, $t\ {}^2G^\circ$, $r\ {}^2G^\circ$, $q\ {}^2G^\circ$, $y\ {}^2H^\circ$, $x\ {}^2H^\circ$, $w\ {}^2H^\circ$, $v\ {}^2H^\circ$, $t\ {}^2H^\circ$, $y\ {}^2I^\circ$, 214°, 400°, 411°, 414°, 416°, 475°.
	$a\ {}^4G_{9/2}$	12357.70	220.84	1.23	
	$a\ {}^4G_{11/2}$	13012.20	654.50	1.26	
d^3s^2	$a\ {}^2H_{11/2}$	12102.12	400.85	0.93	$z\ {}^2F^\circ$, $w\ {}^2F^\circ$, $v\ {}^2F^\circ$, $u\ {}^2F^\circ$, $p\ {}^2F^\circ$, $y\ {}^2G^\circ$, $w\ {}^2G^\circ$, $v\ {}^2G^\circ$, $u\ {}^2G^\circ$, $t\ {}^2G^\circ$, $s\ {}^2G^\circ$, $r\ {}^2G^\circ$, $q\ {}^2G^\circ$, $p\ {}^2G^\circ$, $o\ {}^2G^\circ$, $n\ {}^2G^\circ$, $z\ {}^2H^\circ$, $y\ {}^2H^\circ$, $x\ {}^2H^\circ$, $w\ {}^2H^\circ$, $v\ {}^2H^\circ$, $u\ {}^2H^\circ$, $z\ {}^2I^\circ$, $y\ {}^2I^\circ$, $w\ {}^4D^\circ$, $v\ {}^4D^\circ$, $y\ {}^4F^\circ$, $x\ {}^4F^\circ$, $w\ {}^4F^\circ$, $v\ {}^4F^\circ$, $u\ {}^4F^\circ$, $t\ {}^4F^\circ$, $s\ {}^4F^\circ$, $q\ {}^4F^\circ$, $p\ {}^4F^\circ$, $y\ {}^4G^\circ$, $w\ {}^4G^\circ$, $v\ {}^4G^\circ$, $u\ {}^4G^\circ$, $t\ {}^4G^\circ$, $s\ {}^4G^\circ$, $y\ {}^4H^\circ$, $x\ {}^4H^\circ$, $z\ {}^4I^\circ$, 411°.
	$a\ {}^2H_{13/2}$	12502.97		1.10	

TABLE 6.—*Terms of the* Cb I *spectrum*—Continued

Electron configuration	Term symbol	Level	Difference	Observed g	Combinations
					$z\,^4P^\circ$, $z\,^4P^\circ$, $w\,^4P^\circ$, $y\,^4D^\circ$, $x\,^4D^\circ$, $w\,^4D^\circ$, $s\,^4D^\circ$, $u\,^4D^\circ$, $t\,^4D^\circ$, $s\,^4D^\circ$, $r\,^4D^\circ$, $q\,^4D^\circ$, $p\,^4D^\circ$, $o\,^4D^\circ$, $n\,^4D^\circ$, $z\,^4F^\circ$, $y\,^4F^\circ$, $x\,^4F^\circ$, $w\,^4F^\circ$, $s\,^4F^\circ$, $u\,^4F^\circ$, $t\,^4F^\circ$, $s\,^4F^\circ$, $r\,^4F^\circ$, $q\,^4F^\circ$, $p\,^4F^\circ$, $o\,^4F^\circ$, $z\,^4G^\circ$, $y\,^4G^\circ$, $x\,^4G^\circ$, $w\,^4G^\circ$, $s\,^4G^\circ$, $u\,^4G^\circ$, $t\,^4G^\circ$, $s\,^4G^\circ$, $z\,^4H^\circ$, $y\,^4H^\circ$, $x\,^4H^\circ$, $y\,^4D^\circ$, $x\,^2D^\circ$, $y\,^2F^\circ$, $y\,^2S^\circ$, $y\,^2P^\circ$, $z\,^2P^\circ$, $z\,^2D^\circ$, $y\,^2D^\circ$, $s\,^2D^\circ$, $u\,^2D^\circ$, $t\,^2D^\circ$, $s\,^2D^\circ$, $z\,^2F^\circ$, $y\,^2F^\circ$, $w\,^2F^\circ$, $s\,^2F^\circ$, $u\,^2F^\circ$, $r\,^2F^\circ$, $q\,^2F^\circ$, $p\,^2F^\circ$, $n\,^2F^\circ$, $m\,^2F^\circ$, $z\,^2G^\circ$, $w\,^2G^\circ$, $s\,^2G^\circ$, $u\,^2G^\circ$, $t\,^2G^\circ$, $r\,^2G^\circ$, $p\,^2G^\circ$, $z\,^2H^\circ$, $y\,^2H^\circ$, $x\,^2H^\circ$, $w\,^2H^\circ$, $s\,^2H^\circ$, $u\,^2H^\circ$, $t\,^2H^\circ$, $y\,^2I^\circ$, 276°, 400°, 411°, 414°, 416°, 475°.
$d^3\,s^2$	$a\,^2F_{2\frac{1}{2}}$	13404.77	110.43	0.860	$x\,^2P^\circ$, $y\,^2D^\circ$, $x\,^2D^\circ$, $w\,^2D^\circ$, $s\,^2D^\circ$, $u\,^2D^\circ$, $t\,^2D^\circ$, $s\,^2D^\circ$, $z\,^2F^\circ$, $y\,^2F^\circ$, $x\,^2F^\circ$, $w\,^2F^\circ$, $s\,^2F^\circ$, $u\,^2F^\circ$, $t\,^2F^\circ$, $s\,^2F^\circ$, $r\,^2F^\circ$, $q\,^2F^\circ$, $p\,^2F^\circ$, $n\,^2F^\circ$, $m\,^2F^\circ$, $z\,^2G^\circ$, $y\,^2G^\circ$, $x\,^2G^\circ$, $w\,^2G^\circ$, $s\,^2G^\circ$, $u\,^2G^\circ$, $t\,^2G^\circ$, $s\,^2G^\circ$, $r\,^2G^\circ$, $q\,^2G^\circ$, $n\,^2G^\circ$, $w\,^2H^\circ$, $s\,^2H^\circ$, $t\,^2H^\circ$, $x\,^4P^\circ$, $y\,^4D^\circ$, $x\,^4D^\circ$, $w\,^4D^\circ$, $s\,^4D^\circ$, $u\,^4D^\circ$, $t\,^4D^\circ$, $s\,^4D^\circ$, $r\,^4D^\circ$, $p\,^4D^\circ$, $o\,^4D^\circ$, $z\,^4F^\circ$, $w\,^4F^\circ$, $s\,^4F^\circ$, $u\,^4F^\circ$, $t\,^4F^\circ$, $p\,^4F^\circ$, $q\,^4F^\circ$, $w\,^4G^\circ$, $s\,^4G^\circ$, $u\,^4G^\circ$, $t\,^4G^\circ$, $s\,^4G^\circ$, $r\,^4G^\circ$, $x\,^4H^\circ$, $x\,^4I^\circ$, $y\,^4D^\circ$, $x\,^2D^\circ$, 276°, 400°, 411°, 416°.
$d^3\,s\,(^3P)$	$b\,^4P_{2\frac{1}{2}}$	13629.15	582.15	2.64	$z\,^4S^\circ$, $y\,^4S^\circ$, $w\,^4S^\circ$, $y\,^4P^\circ$, $x\,^4P^\circ$, $w\,^4P^\circ$, $y\,^4D^\circ$, $x\,^4D^\circ$, $w\,^4D^\circ$, $v\,^4D^\circ$, $u\,^4D^\circ$, $s\,^4D^\circ$, $r\,^4D^\circ$, $q\,^4D^\circ$, $o\,^4D^\circ$, $n\,^4D^\circ$, $x\,^4F^\circ$, $w\,^4F^\circ$, $v\,^4F^\circ$, $u\,^4F^\circ$, $t\,^4F^\circ$, $r\,^4F^\circ$, $q\,^4F^\circ$, $p\,^4F^\circ$, $o\,^4F^\circ$, $n\,^4F^\circ$, $s\,^4G^\circ$, $r\,^4G^\circ$, $z\,^4H^\circ$, $z\,^4S^\circ$, $y\,^2D^\circ$, $x\,^2D^\circ$, $w\,^2P^\circ$, $v\,^2P^\circ$, $w\,^2D^\circ$, $v\,^2D^\circ$, $z\,^2F^\circ$, 276°, 400°, 416°, 469°.
$d^3\,s\,(^3P)$	$b\,^4P_{1\frac{1}{2}}$	14211.30	687.96	1.71	
$d^3\,s\,(^3P)$	$b\,^4P_{\frac{1}{2}}$	14899.26		1.54	
$d^3\,s\,(^3D)$	$b\,^4D_{3\frac{1}{2}}$	15460.77	−21.52	0.04	$z\,^4S^\circ$, $w\,^4S^\circ$, $y\,^4P^\circ$, $x\,^4P^\circ$, $w\,^4P^\circ$, $y\,^4D^\circ$, $x\,^4D^\circ$, $w\,^4D^\circ$, $v\,^4D^\circ$, $u\,^4D^\circ$, $s\,^4D^\circ$, $r\,^4D^\circ$, $q\,^4D^\circ$, $p\,^4D^\circ$, $n\,^4D^\circ$, $y\,^4F^\circ$, $x\,^4F^\circ$, $w\,^4F^\circ$, $v\,^4F^\circ$, $u\,^4F^\circ$, $t\,^4F^\circ$, $s\,^4F^\circ$, $r\,^4F^\circ$, $q\,^4F^\circ$, $p\,^4F^\circ$, $o\,^4F^\circ$, $y\,^4G^\circ$, $w\,^4G^\circ$, $v\,^4G^\circ$, $t\,^4G^\circ$, $s\,^4G^\circ$, $r\,^4G^\circ$, $z\,^4H^\circ$, $y\,^4D^\circ$, $y\,^2S^\circ$, $z\,^2P^\circ$, $y\,^2P^\circ$, $z\,^2P^\circ$, $w\,^2P^\circ$, $v\,^2P^\circ$, $z\,^2D^\circ$, $y\,^2D^\circ$, $v\,^2D^\circ$, $z\,^2F^\circ$, $q\,^2F^\circ$, $p\,^2F^\circ$, $m\,^2F^\circ$, $x\,^2G^\circ$, $t\,^2G^\circ$, $s\,^2G^\circ$, $r\,^2G^\circ$, 411°, 414°, 416°, 469°, 475°.
$d^3\,s\,(^3D)$	$b\,^4D_{2\frac{1}{2}}$	15439.25	27.83	1.21	
$d^3\,s\,(^3D)$	$b\,^4D_{1\frac{1}{2}}$	15467.08	−184.73	1.42	
$d^3\,s\,(^3D)$	$b\,^4D_{\frac{1}{2}}$	15282.35		1.43	
$d^3\,s\,(^3H)$	$b\,^3H_{4\frac{1}{2}}$	16828.52	647.70	1.04	$w\,^2F^\circ$, $r\,^2F^\circ$, $q\,^2F^\circ$, $p\,^2F^\circ$, $m\,^2F^\circ$, $z\,^2G^\circ$, $y\,^2G^\circ$, $x\,^2G^\circ$, $w\,^2G^\circ$, $v\,^2G^\circ$, $u\,^2G^\circ$, $t\,^2G^\circ$, $s\,^2G^\circ$, $r\,^2G^\circ$, $p\,^2G^\circ$, $o\,^2G^\circ$, $z\,^2H^\circ$, $y\,^2H^\circ$, $x\,^2H^\circ$, $w\,^2H^\circ$, $v\,^2H^\circ$, $u\,^2H^\circ$, $t\,^2H^\circ$, $z\,^2I^\circ$, $y\,^2I^\circ$, $q\,^4D^\circ$, $y\,^4F^\circ$, $x\,^4F^\circ$, $r\,^4F^\circ$, $q\,^4F^\circ$, $w\,^4G^\circ$, $v\,^4G^\circ$, $u\,^4G^\circ$, $t\,^4G^\circ$, $s\,^4G^\circ$, $y\,^4H^\circ$, $x\,^4H^\circ$, 411°.
$d^3\,s\,(^3H)$	$b\,^3H_{3\frac{1}{2}}$	17476.22		1.01	
$d^3\,s\,(^3G)$	$b\,^3G_{3\frac{1}{2}}$	16918.78	1117.19	0.88	$u\,^2D^\circ$, $t\,^2D^\circ$, $v\,^2F^\circ$, $s\,^2F^\circ$, $r\,^2F^\circ$, $q\,^2F^\circ$, $p\,^2F^\circ$, $m\,^2F^\circ$, $z\,^2G^\circ$, $y\,^2G^\circ$, $u\,^2G^\circ$, $t\,^2G^\circ$, $s\,^2G^\circ$, $r\,^2G^\circ$, $p\,^2G^\circ$, $o\,^2G^\circ$, $z\,^2H^\circ$, $y\,^2H^\circ$, $x\,^2H^\circ$, $w\,^2H^\circ$, $v\,^2H^\circ$, $t\,^2H^\circ$, $z\,^2I^\circ$, $s\,^4D^\circ$, $q\,^4D^\circ$, $p\,^4D^\circ$, $o\,^4D^\circ$, $x\,^4F^\circ$, $s\,^4F^\circ$, $u\,^4F^\circ$, $t\,^4F^\circ$, $r\,^4F^\circ$, $y\,^4G^\circ$, $x\,^4G^\circ$, $w\,^4G^\circ$, $v\,^4G^\circ$, $u\,^4G^\circ$, $s\,^4G^\circ$, $r\,^4G^\circ$, $z\,^4H^\circ$, $y\,^4H^\circ$, $y\,^2D^\circ$, $z\,^2D^\circ$, 411°, 416°.
$d^3\,s\,(^3G)$	$b\,^3G_{4\frac{1}{2}}$	18035.97		0.97	
	$153_{2\frac{1}{2}}$	18332.04			$y\,^2G^\circ$, $w\,^2G^\circ$, $t\,^2G^\circ$, $s\,^2G^\circ$, $r\,^2G^\circ$, $o\,^2G^\circ$, $n\,^2G^\circ$, $z\,^2H^\circ$, $y\,^2H^\circ$, $x\,^2H^\circ$, $w\,^2H^\circ$, $v\,^2H^\circ$, $z\,^2H^\circ$, $v\,^2F^\circ$, $u\,^4F^\circ$, $s\,^4F^\circ$, $x\,^4G^\circ$, $t\,^4G^\circ$, $r\,^4G^\circ$.
$d^3\,sp\,(^3F)$	$z\,^4G^\circ_{5\frac{1}{2}}$	*16672.00*	309.01	0.00	$e\,^6F$.
	$z\,^4G^\circ_{4\frac{1}{2}}$	*16981.01*	322.95		
	$z\,^4G^\circ_{3\frac{1}{2}}$	*17303.96*	633.30		
	$z\,^4G^\circ_{2\frac{1}{2}}$	*17937.26*	497.88		
	$z\,^4G^\circ_{1\frac{1}{2}}$	*18435.14*	441.32		
	$z\,^4G^\circ_{\frac{1}{2}}$	*18876.46*			
$d^3\,sp\,(^3F)$	$z\,^6F^\circ_{5\frac{1}{2}}$	*18791.09*	245.46	−0.373	$a\,^6D$, $e\,^6D$, $e\,^6F$, $a\,^4P$, $a\,^4D$, $a\,^4F$, $a\,^2G$.
	$z\,^6F^\circ_{4\frac{1}{2}}$	*19036.55*	391.35	1.35	
	$z\,^6F^\circ_{3\frac{1}{2}}$	*19427.90*	488.79	1.39	
	$z\,^6F^\circ_{2\frac{1}{2}}$	*19916.69*	515.42	1.44	
	$z\,^6F^\circ_{1\frac{1}{2}}$	*20431.11*			
	$z\,^6F^\circ_{\frac{1}{2}}$	----------			
$d^3\,sp\,(^3F)$	$z\,^6D^\circ_{5\frac{1}{2}}$	*19683.96*	141.22	3.01	$a\,^6D$, $e\,^6F$, $a\,^4P$, $a\,^4D$, $a\,^4F$.
	$z\,^6D^\circ_{4\frac{1}{2}}$	*19765.15*	228.60	1.72	
	$z\,^6D^\circ_{3\frac{1}{2}}$	*19993.78*	321.96	1.56	
	$z\,^6D^\circ_{2\frac{1}{2}}$	*20315.74*	418.14	1.55	
	$z\,^6D^\circ_{1\frac{1}{2}}$	*20733.88*		1.54	

TABLE 6.—*Terms of the* Cb I *spectrum*—Continued

Electron configuration	Term symbol	Level	Difference	Observed g	Combinations
$6sp$ (^3F)	$z\ ^4D_{5/2}$	20107.36		−0.02	
	$z\ ^4D_{3/2}$	20383.62	276.26	1.26	$a\ ^4P$, $a\ ^4D$, $a\ ^4F$, $a\ ^4G$, $a\ ^6D$, $a\ ^2G$.
	$z\ ^4D_{1/2}$	20857.98	454.36	1.39	
	$z\ ^4D_{3/2}$	21512.18	674.20	1.44	
$6p$ (^3D)	$z\ ^4P_{5/2}$	22006.74		2.47	
	$z\ ^4P_{3/2}$	23006.86	1000.12	1.61	$a\ ^4P$, $a\ ^4D$, $a\ ^4F$, $a\ ^6D$, $a\ ^2P$, $a\ ^2D$.
	$z\ ^4P_{1/2}$	23684.44	677.58	1.477	
$6sp$ (^3F)	$z\ ^4G_{5/2}$	22647.03		0.578	
	$z\ ^4G_{7/2}$	23022.56	375.53	0.98	$a\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$, $a\ ^6D$, $a\ ^2G$.
	$z\ ^4G_{9/2}$	23536.77	514.21	1.15	
	$z\ ^4G_{11/2}$	24203.05	666.28	1.25	
$6sp$ (^3F)	$z\ ^4F_{3/2}$	23243.87		0.416	
	$z\ ^4F_{5/2}$	23574.14	330.27	1.061	$a\ ^4P$, $a\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$, $a\ ^6D$, $a\ ^2P$, $a\ ^2D$, $a\ ^2G$.
	$z\ ^4F_{7/2}$	24015.11	440.97	1.243	
	$z\ ^4F_{9/2}$	24506.53	491.42	1.336	
$6p$ (^3P)	$z\ ^2D_{5/2}$	23525.80		0.898	
	$z\ ^2D_{3/2}$	24773.03	1247.23	1.30	$a\ ^2P$, $a\ ^2D$, $a\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^6D$.
$6p$ (^3P)	$z\ ^2S_{1/2}$	23910.90		2.123	$a\ ^2P$, $a\ ^2D$, $a\ ^4P$, $a\ ^4D$, $a\ ^6D$.
$6p$ (^1D)	$y\ ^6F_{3/2}$	23984.87		−0.601	
	$y\ ^6F_{5/2}$	24164.79	179.92	1.060	
	$y\ ^6F_{7/2}$	24396.80	232.01	1.306	
	$y\ ^6F_{9/2}$	24769.91	373.11	1.380	$a\ ^6S$, $a\ ^6D$, $e\ ^6D$, $a\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^2P$, $a\ ^2D$.
	$y\ ^6F_{11/2}$	25199.81	429.90	1.427	
	$y\ ^6F_{13/2}$	25680.36	480.55	1.450	
$6p$ (^1D)	$z\ ^4P_{5/2}$	24483.34		2.382	
	$z\ ^4P_{3/2}$	24543.13	259.79	1.874	$a\ ^6S$, $a\ ^6D$, $e\ ^6D$, $a\ ^4P$, $a\ ^4D$, $a\ ^4F$.
	$z\ ^4P_{1/2}$	24904.86	361.73	1.703	
$6sp$ (^3P)	$y\ ^6D_{9/2}$	25879.81		3.22	
	$y\ ^6D_{7/2}$	26067.06	187.25	1.820	
	$y\ ^6D_{5/2}$	26386.36	319.30	1.610	$a\ ^6D$, $e\ ^6D$, $a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^2F$, $a\ ^2G$, $b\ ^2G$, $b\ ^2H$.
	$y\ ^6D_{3/2}$	26832.43	446.07	1.248	
	$y\ ^6D_{1/2}$	27419.62	587.19	1.422	
$6p$ (^1D)	$y\ ^4F_{3/2}$	25930.01		0.467	
	$y\ ^4F_{5/2}$	26060.66	130.64	1.085	
	$y\ ^4F_{7/2}$	26165.79	105.14	1.245	$a\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^6D$, $a\ ^2P$, $a\ ^2G$, $a\ ^2H$, $b\ ^2H$.
	$y\ ^4F_{9/2}$	26440.33	274.54	1.334	
$6p$ (^1D)	$z\ ^6D_{9/2}$	26552.40		2.441	
	$z\ ^6D_{7/2}$	26713.32	160.92	1.45	
	$z\ ^6D_{5/2}$	26983.34	270.02	1.618	$a\ ^6D$, $a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^2D$, $b\ ^2G$.
	$z\ ^6D_{3/2}$	27427.07	443.73	1.567	
	$z\ ^6D_{1/2}$	27974.87	547.80	1.542	
$6p$ (^1D)	$y\ ^4D_{5/2}$	26717.73		1.141	
	$y\ ^4D_{3/2}$	26936.86	219.13	1.292	
	$y\ ^4D_{1/2}$	27359.70	422.84	1.32	$a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^6D$, $a\ ^2P$, $a\ ^2D$, $a\ ^2F$, $a\ ^2G$.
	$y\ ^4D_{7/2}$	27596.74	237.04	1.422	
$6p$ (^3H)	$z\ ^2G_{9/2}$	26896.68		1.013	$a\ ^2F$, $a\ ^2G$, $b\ ^2G$, $b\ ^2H$, $a\ ^4P$, $a\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^6D$.
	$z\ ^2G_{7/2}$	27331.80	435.12	1.078	
$6sp$ ($e\ ^3P$)	$y\ ^4P_{5/2}$	27498.94		2.467	
	$y\ ^4P_{3/2}$	27782.57	283.63	1.660	$a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $a\ ^4F$, $a\ ^6S$, $a\ ^6D$, $a\ ^2P$, $a\ ^2D$.
	$y\ ^4P_{1/2}$	28445.33	662.76	1.606	
	$276b_{5/2}$	27614.10		1.370	$b\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $a\ ^6D$, $a\ ^2D$, $a\ ^2F$, $a\ ^2G$.
$6sp$ ($e\ ^3P$)	$z\ ^4D_{3/2}$	27666.46		0.222	
	$z\ ^4D_{5/2}$	28079.09	412.63	1.443	
	$z\ ^4D_{7/2}$	28549.42	470.33	1.472	$a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^6D$, $a\ ^2P$, $a\ ^2D$, $a\ ^2G$.
	$z\ ^4D_{1/2}$	29209.42	660.00	1.241	
$6sp$ (^3F)	$z\ ^2F_{5/2}$	27797.44	737.92	1.16	$a\ ^2F$, $a\ ^2G$, $a\ ^2H$, $a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^6D$.
	$z\ ^2F_{7/2}$	28535.36		1.12	
$6sp$ (^3F)	$y\ ^2G_{9/2}$	27855.13	578.61	0.92	$a\ ^2F$, $a\ ^2G$, $b\ ^2G$, $a\ ^2H$, $b\ ^2H$, 183, $a\ ^4P$, $a\ ^4D$, $a\ ^4F$, $a\ ^4G$, $a\ ^6D$.
	$y\ ^2G_{7/2}$	28433.74		1.12	
	$z\ ^2P_{3/2}$	28449.16	−523.31	0.772	$a\ ^2P$, $a\ ^2D$, $a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $a\ ^6S$, $a\ ^6D$.
	$z\ ^2P_{1/2}$	27918.85		1.450	
$6p$ (^3P)	$z\ ^4S_{3/2}$	28308.48		1.794	$a\ ^4P$, $b\ ^4P$, $b\ ^4D$, $a\ ^4F$, $a\ ^6S$, $a\ ^6D$, $a\ ^2D$.

TABLE 6.—*Terms of the* Cb I *spectrum*—Continued

Electron configuration	Term symbol	Level	Difference	Observed σ	Combinations
$d^3\,sp\ (^1P)$	$y\ ^6P^0_{7/2}$	28278.25	374.41	1.981	a ^6S, a ^6D, a ^6P, b ^4P, a ^4D, a ^4F, a ^2D.
	$y\ ^6P^0_{5/2}$	28652.66	320.46	1.768	
	$y\ ^6P^0_{3/2}$	28973.12		1.701	
$d^3\,sp\ (^3G)$	$z\ ^4H^0_{13/2}$	29271.99	247.06	0.890	a ^4P, b ^4P, a ^4D, b ^4D, a ^4F, b ^4F, a ^4G, a ^4H, a ^4I, a ^2G, b ^2G.
	$z\ ^4H^0_{11/2}$	29519.05	327.25	1.01	
	$z\ ^4H^0_{9/2}$	29846.30	344.75	1.15	
	$z\ ^4H^0_{7/2}$	30191.25		1.23	
$d^4\,p\ (^2H)$	$y\ ^4G^0_{11/2}$	29359.58	403.12	0.693	a ^4P, a ^4D, b ^4D, a ^4F, b ^4F, a ^4G, a ^4H, a ^6D, a ^2G, b ^2G, a ^2H.
	$y\ ^4G^0_{9/2}$	29762.70	354.62	0.999	
	$y\ ^4G^0_{7/2}$	30117.32	340.28	1.276	
	$y\ ^4G^0_{5/2}$	30457.60		1.25	
$d^3\,sp\ (^3F)$	$y\ ^2D^0_{5/2}$	29622.73	153.07	0.81	a ^2P, a ^2D, a ^2F, a ^2G, a ^4P, a ^4D, b ^4D, a ^4F, b ^4F, a ^4G, a ^6S.
	$y\ ^2D^0_{3/2}$	29775.80		1.348	
$d^4\,p\ (^3F)$	$x\ ^4F^0_{7/2}$	29779.44	208.01	0.42	a ^4P, b ^4P, a ^4D, b ^4D, a ^4F, b ^4F, a ^4G, a ^4H, a ^6D, a ^2F, a ^2G, b ^2G, a ^2H, b ^2H.
	$x\ ^4F^0_{5/2}$	29987.45	174.11	1.006	
	$x\ ^4F^0_{3/2}$	30161.56	117.67	1.18	
	$x\ ^4F^0_{1/2}$	30279.23		1.20	
$d^3\,sp\ (^5P)$	$z\ ^6S^0_{5/2}$	30059.60			a ^6D, a ^4P, b ^4P, a ^4F, a ^2P, a ^2D.
$d^4\,p\ (^1D)$	$y\ ^2F^0_{7/2}$	30716.50	309.02	0.891	a ^2P, a ^2D, a ^2F, a ^2G, a ^4P, a ^4D, a ^4F, a ^4G.
	$y\ ^2F^0_{5/2}$	31025.52		1.139	
$d^3\,sp\ (^3F)$	$x\ ^4G^0_{11/2}$	31056.60	428.60	0.630	a ^4D, a ^4F, b ^4F, a ^4G, a ^4H, a ^6S, a ^6D, a ^2D, a ^2G, b ^2G, 183.
	$x\ ^4G^0_{9/2}$	31485.20	519.43	1.012	
	$x\ ^4G^0_{7/2}$	32004.63	368.09	1.160	
	$x\ ^4G^0_{5/2}$	32372.72		1.24	
$d^3\,sp\ (c\ ^3P)$	$y\ ^6S^0_{5/2}$	31174.65		1.057	a ^4P, b ^4P, a ^4F, a ^6D, a ^2D.
$d^3\,sp\ (^1G)$	$x\ ^2F^0_{7/2}$	----			a ^2D, a ^2F, a ^2G, a ^4D.
	$x\ ^2F^0_{5/2}$	31687.53		1.20	
$d^3\,sp\ (^1G)$	$z\ ^2G^0_{9/2}$	31800.74	413.20	0.906	a ^2F, a ^2G, b ^2H, a ^4P, b ^4D, a ^4F, a ^4H.
	$z\ ^2G^0_{7/2}$	32213.94		1.092	
$d^4\,p\ (^1G)$	$w\ ^2F^0_{7/2}$	31933.68	153.90	0.982	a ^2P, a ^2D, a ^2F, a ^2G, a ^2H, b ^2H, a ^4P, a ^4D, a ^4F, b ^4F, a ^4G, a ^4H.
	$w\ ^2F^0_{5/2}$	32087.58		1.074	
$d^3\,sp\ (^3F)$	$w\ ^4F^0_{9/2}$	31551.46	461.94	0.501	a ^4P, b ^4P, a ^4D, b ^4D, a ^4F, b ^4F, a ^4G, a ^4H, a ^6D, a ^2P, a ^2D, a ^2F, a ^2G, a ^2H.
	$w\ ^4F^0_{7/2}$	32013.40	319.78	1.01	
	$w\ ^4F^0_{5/2}$	32333.18	200.69	1.199	
	$w\ ^4F^0_{3/2}$	32983.87		1.24	
$d^4\,p\ (^3D)$	$x\ ^4F^0_{7/2}$	31707.94	99.61	0.80	a ^4P, b ^4P, a ^4D, b ^4D, a ^4F, b ^4F, a ^4G, a ^4H, a ^6D, a ^2P, a ^2D, a ^2F, a ^2G, b ^2G, a ^2H, 183.
	$x\ ^4F^0_{5/2}$	31807.55	165.69	1.048	
	$x\ ^4F^0_{3/2}$	31973.24	632.15	1.343	
	$x\ ^4F^0_{1/2}$	32605.39		1.216	
$d^4\,p\ (^3G)$	$u\ ^4F^0_{7/2}$	31907.74	232.04	0.791	a ^4P, b ^4P, a ^4D, b ^4D, a ^4F, b ^4F, a ^4G, a ^4H, a ^2P, a ^2D, a ^2F, a ^2G, b ^2G, a ^2H, 183.
	$u\ ^4F^0_{5/2}$	32139.78	312.21	1.035	
	$u\ ^4F^0_{3/2}$	32451.99	684.31	1.115	
	$u\ ^4F^0_{1/2}$	33136.30		1.240	
$d^4\,p\ (^3P)$	$w\ ^4D^0_{3/2}$	32066.06	182.63	0.046	a ^4P, b ^4P, a ^4D, b ^4D, a ^4F, b ^4F, a ^4G, a ^6D, a ^2P, a ^2D, a ^2F, a ^2G, a ^2H.
	$w\ ^4D^0_{1/2}$	32248.69	296.83	1.184	
	$w\ ^4D^0_{5/2}$	32545.52	458.37	1.320	
	$w\ ^4D^0_{7/2}$	33003.89		1.341	
$d^4\,p\ (^2H)$	$z\ ^4D^0_{1/2}$	32156.00	226.24	0.835	a ^4F, a ^4G, a ^4H, a ^2F, a ^2G, a ^2H.
	$z\ ^4D^0_{3/2}$	32382.24	290.15	0.993	
	$z\ ^4D^0_{5/2}$	32672.39	443.97	1.08	
	$z\ ^4D^0_{7/2}$	33116.36		1.19	
$d^4\,p\ (^3F)$	$w\ ^4G^0_{5/2}$	----			a ^4P, a ^4D, b ^4D, a ^4F, b ^4F, a ^4G, a ^4H, a ^6D, a ^2D, a ^2F, a ^2G, b ^2G, a ^2H.
	$w\ ^4G^0_{7/2}$	32501.33	301.11	1.06	
	$w\ ^4G^0_{9/2}$	32802.44	625.76	1.21	
	$w\ ^4G^0_{11/2}$	33428.20		1.27	
$d^3\,sp\ (^1P)$	$x\ ^2D^0_{3/2}$	32623.02		1.00	a ^2P, a ^2D, a ^2F, a ^4P, a ^4D, a ^4F, a ^4G, a ^6D.
	$x\ ^2D^0_{5/2}$	----			
$d^4\,p\ (^5G)$	$v\ ^2F^0_{5/2}$	32654.48	244.60	0.830	a ^2P, a ^2D, a ^2F, a ^2G, b ^2G, a ^2H, a ^4P, a ^4D, a ^4F, b ^4F, a ^4G, a ^4H, a ^6S.
	$v\ ^2F^0_{7/2}$	32899.08		1.17	

TABLE 6.—*Terms of the* Cb I *spectrum*—Continued

Electron configuration	Term symbol	Level	Difference	Observed g	Combinations
fsp (^{3}F)	$v\ ^4D_{3/2}$	*32011.45*		0.46	
	$v\ ^4D_{1/2}$	*32717.01*	705.56	1.230	$a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^6D$, $a\ ^2D$,
	$v\ ^4D_{5/2}$	*32872.18*	155.17	1.350	$a\ ^2F$, $a\ ^2G$, $a\ ^2H$.
	$v\ ^4D_{3/2}$	*33168.94*	296.76	1.390	
fsp (^{1}D)	$w\ ^2D_{1/2}$	*33086.98*		1.058	
	$w\ ^2D_{3/2}$	*33389.87*	302.89	1.212	$a\ ^2P$, $a\ ^2D$, $a\ ^2F$, $a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $a\ ^4F$, $a\ ^4G$.
fsp ($c\ ^3$P)	$y\ ^2P_{3/2}$	*33902.24*		0.442	
	$y\ ^2P_{1/2}$	*34252.96*	350.72		$a\ ^2P$, $a\ ^2D$, $a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$.
fsp (^{1}H)	$z\ ^2H_{11/2}$	*34004.08*		0.946	
	$z\ ^2H_{9/2}$	*34323.20*	319.12	1.08	$a\ ^2G$, $b\ ^2G$, $a\ ^2H$, $b\ ^2H$, 183, $a\ ^4F$, $a\ ^4H$.
fsp (^{1}H)	$w\ ^2G_{9/2}$	*34319.09*		0.87	
	$w\ ^2G_{7/2}$	*34235.04*	−84.05	1.10	$a\ ^2F$, $a\ ^2G$, $a\ ^2H$, $b\ ^2H$, 183, $a\ ^4P$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$, $a\ ^6D$.
fsp (^{3}H)	$z\ ^2H_{11/2}$	*34415.52*		0.819	
	$z\ ^2H_{9/2}$	*34838.33*	422.81	1.01	$a\ ^2G$, $b\ ^2G$, $a\ ^2H$, $b\ ^2H$, 183, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$.
fsp (^{3}P)	$x\ ^4P_{5/2}$	*34614.22*		2.05	
	$x\ ^4P_{3/2}$	*34867.68*	223.46	1.587	$a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^2P$, e-D,
	$x\ ^4P_{1/2}$	*34703.70*	−163.98	1.55	$a\ ^2F$.
fp (^{3}G)	$v\ ^4G_{5/2}$	*34654.79*		0.627	
	$v\ ^4G_{7/2}$	*34853.50*	198.71	1.000	$a\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$, $a\ ^2P$, $a\ ^2D$,
	$v\ ^4G_{9/2}$	*35156.94*	303.44	1.073	$a\ ^2F$, $a\ ^2G$, $b\ ^2G$, $a\ ^2H$, $b\ ^2H$.
	$v\ ^4G_{11/2}$	*35630.62*	473.68	1.160	
fsp ($b\ ^3$P)	$v\ ^2D_{3/2}$	*34752.70*		0.948	
	$v\ ^2D_{5/2}$	*35497.48*	744.78	1.160	$a\ ^2P$, $a\ ^2D$, $a\ ^2F$, $a\ ^2G$, $a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$.
fsp ($c\ ^3$P)	$y\ ^2S_{1/2}$	*34807.87*		2.080	$a\ ^2D$, $a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$.
fsp (^{1}D)	$u\ ^2F_{5/2}$	*35099.86*		0.868	
	$u\ ^2F_{7/2}$	*35178.82*	78.96	1.117	$a\ ^2P$, $a\ ^2D$, $a\ ^2F$, $a\ ^2G$, $a\ ^2H$, $a\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$.
fsp($b\ ^3$P)	$x\ ^4S_{3/2}$	*35119.65*		1.806	$a\ ^4P$, $a\ ^4D$, $a\ ^4F$, $a\ ^2D$.
fp (^{3}G)	$y\ ^2H_{9/2}$	*35496.39*		0.954	
	$y\ ^2H_{11/2}$	*35344.86*	−151.53	1.125	$a\ ^2G$, $b\ ^2G$, $a\ ^2H$, $b\ ^2H$, 183, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$, $a\ ^6D$.
fp (^{3}F)	$u\ ^2D_{3/2}$	*35829.46*		0.834	
	$u\ ^2D_{5/2}$	*35928.35*	98.89	1.17	$a\ ^2P$, $a\ ^2D$, $a\ ^2F$, $a\ ^2G$, $b\ ^2G$, $a\ ^4P$, $a\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$.
fp (^{3}F)	$u\ ^4D_{7/2}$	*35920.45*		0.019	
	$u\ ^4D_{5/2}$	*36016.26*	95.81	1.195	a^5_4P, $b\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$, $a\ ^6S$,
	$u\ ^4D_{3/2}$	*36180.13*	163.87	1.316	$a\ ^2P$, $a\ ^2D$, $a\ ^2F$.
	$u\ ^4D_{1/2}$	*36334.21*	154.08	1.378	
fsp (^{3}G)	$v\ ^2G_{9/2}$	*36048.10*		0.925	
	$v\ ^2G_{7/2}$	*36333.70*	285.60	1.086	$a\ ^2D$, $a\ ^2F$, $a\ ^2G$, $a\ ^2H$, $b\ ^2H$, $a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$.
fp (^{1}G)	$x\ ^2H_{11/2}$	----			
	$x\ ^2H_{9/2}$	*36375.77*		1.14	$a\ ^2G$, $b\ ^2G$, $a\ ^2H$, $b\ ^2H$, 183, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$.
fsp (^{1}P)	$w\ ^4S_{3/2}$	*36371.05*		1.948	$a\ ^4P$, $b\ ^4P$, $b\ ^4D$, $a\ ^2D$.
fp (^{3}H)	$y\ ^4H_{13/2}$	*36460.34*		0.691	
	$y\ ^4H_{11/2}$	*36717.11*	256.77	0.970	
	$y\ ^4H_{9/2}$	*36976.10*	258.99	1.15	$a\ ^4P$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$, $a\ ^2G$, $b\ ^2G$, $a\ ^2H$, $b\ ^2H$.
	$y\ ^4H_{7/2}$	*37254.41*	278.31	1.23	
fsp (^{3}G)	$t\ ^2F_{5/2}$	----			
	$t\ ^2F_{7/2}$	*36511.49*			$a\ ^2F$, $a\ ^2G$.
fp (^{1}D)	$s\ ^2F_{5/2}$	*36866.60*		0.846	
	$s\ ^2F_{7/2}$	*36979.20*	112.60	1.14	$a\ ^2P$, $a\ ^2D$, $a\ ^2F$, $a\ ^2G$, $b\ ^2G$, $a\ ^4P$, $a\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$.
fp ($c\ ^3$F)	$t\ ^4F_{9/2}$	*37111.67*		0.526	
	$t\ ^4F_{7/2}$	*37286.62*	174.95	0.964	
	$t\ ^4F_{5/2}$	*37539.67*	253.05	1.172	$a\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$, $a\ ^2P$, $a\ ^2D$,
	$t\ ^4F_{3/2}$	*37831.58*	291.91	1.260	$a\ ^2F$, $a\ ^2G$, $b\ ^2G$, $a\ ^2H$, $b\ ^2H$.
fp (^{3}F)	$u\ ^4G_{5/2}$	*37188.28*		0.840	
	$u\ ^4G_{7/2}$	*37343.50*	155.22	1.058	
	$u\ ^4G_{9/2}$	*37523.53*	180.03	1.190	$a\ ^4P$, $a\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$, $a\ ^2P$, $a\ ^2D$, $a\ ^2F$,
	$u\ ^4G_{11/2}$	*37760.60*	237.07	1.25	$a\ ^2G$, $b\ ^2G$, $a\ ^2H$, $b\ ^2H$, 183.

TABLE 6.—*Terms of the* Cb I *spectrum*—Continued

Electron configuration	Term symbol	Level	Difference	Observed g	Combinations
$d^4\,s$ (^{5}D)	$e\ ^6D_{9/2}$	37410.17	168.55		
	$e\ ^6D_{7/2}$	37578.72	263.64		$z\ ^6P^\circ$, $y\ ^6D^\circ$, $z\ ^6F^\circ$, $y\ ^6F^\circ$.
	$e\ ^6D_{5/2}$	37842.36	335.29		
	$e\ ^6D_{3/2}$	38177.65	390.20		
	$e\ ^6D_{1/2}$	38567.85			
$d^4\,p$ (^{5}D)	$t\ ^4D_{9/2}$	37536.58	418.43	0.10	
	$t\ ^4D_{7/2}$	37954.99	438.50	1.051	$a\ ^4P$, $a\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$, $a\ ^6D$, $a\ ^2P$, $a\ ^2D$,
	$t\ ^4D_{5/2}$	38393.49	460.65	1.371	$a\ ^2F$, $a\ ^2G$.
	$t\ ^4D_{3/2}$	38854.14		1.305	
$d^4\,p$ (^{3}G)	$x\ ^4H_{11/2}$	37624.58	241.53	0.706	
	$x\ ^4H_{9/2}$	37866.06	277.70	0.992	$a\ ^4P$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$, $a\ ^2D$, $a\ ^2F$, $a\ ^2G$, $a\ ^2H$,
	$x\ ^4H_{7/2}$	38143.76	370.09	1.089	$b\ ^2H$.
	$x\ ^4H_{5/2}$	38513.85		1.21	
$d^4\,p$ (^{3}F)	$r\ ^2F_{7/2}$	37814.64	417.21	0.876	$a\ ^2D$, $a\ ^2F$, $a\ ^2G$, $b\ ^2G$, $b\ ^2H$, $a\ ^4P$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$,
	$r\ ^2F_{5/2}$	38231.85		1.111	$a\ ^4H$, $a\ ^6D$.
$d^3\,sp$ (^{3}D)	$t\ ^2D_{3/2}$	37865.42	314.90	0.90	$a\ ^2P$, $a\ ^2D$, $a\ ^2F$, $b\ ^2G$, $a\ ^4P$, $a\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4H$.
	$t\ ^2D_{5/2}$	38180.32		1.077	
$d^3\,s$-s	$e\ ^4F_{9/2}$	37871.10	150.11		
	$e\ ^4F_{7/2}$	38021.41	255.18		
	$e\ ^4F_{5/2}$	38276.59	361.88		$z\ ^6D^\circ$, $z\ ^6F^\circ$, $z\ ^6G^\circ$.
	$e\ ^4F_{3/2}$	38638.47	462.26		
	$e\ ^4F_{1/2}$	39100.73	308.15		
	$e\ ^4F_{3/2}$	39408.88			
$d^4\,p$ (^{3}D)	$x\ ^2P_{3/2}$	38182.96	263.82	0.564	$a\ ^2P$, $a\ ^2D$, $a\ ^2F$, $a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$,
	$x\ ^2P_{1/2}$	38446.78		1.29	$a\ ^4G$.
$d^4\,p$ (^{3}H)	$y\ ^2H_{11/2}$	38251.88	331.76	0.97	$a\ ^2G$, $a\ ^2H$, $b\ ^2H$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$.
	$y\ ^2H_{9/2}$	38583.04		1.09	
$d^3\,sp$ (^{1}G)	$w\ ^2H_{11/2}$	38448.77	372.04	0.936	$a\ ^2F$, $a\ ^2G$, $b\ ^2G$, $a\ ^2H$, $b\ ^2H$, 183, $a\ ^4D$, $a\ ^4F$, $b\ ^4F$,
	$w\ ^2H_{9/2}$	38820.81		1.084	$a\ ^4G$, $a\ ^4H$.
$d^4\,p$ (^{3}D)	$w\ ^4P_{5/2}$	38730.16	−20.50	2.55	
	$w\ ^4P_{3/2}$	38709.66	53.08	1.660	$a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^6S$, $a\ ^6D$, $a\ ^2P$, $a\ ^2D$,
	$w\ ^4P_{1/2}$	38763.34		1.588	
$d^3\,sp$ (^{3}G)	$s\ ^4F_{9/2}$	38903.00	345.30	0.448	
	$s\ ^4F_{7/2}$	39248.30	371.83	0.973	$a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$, $a\ ^2D$, $a\ ^2G$, $a\ ^2H$, 183,
	$s\ ^4F_{5/2}$	39620.13	388.39	1.094	
	$s\ ^4F_{3/2}$	40008.52		1.108	
$d^3\,sp$ (^{3}H)	$u\ ^2G_{9/2}$	38932.20	308.57	1.010	$a\ ^2D$, $a\ ^2F$, $a\ ^2G$, $b\ ^2G$, $a\ ^2H$, $b\ ^2H$, $a\ ^4P$, $a\ ^4D$, $a\ ^4F$,
	$u\ ^2G_{7/2}$	39380.77		1.10	$b\ ^4F$, $a\ ^2G$, $a\ ^4H$, $a\ ^6D$.
$d^3\,sp$ ($d\ ^3$F)	$t\ ^2G_{7/2}$	39426.84	210.92	0.91	$a\ ^2F$, $a\ ^2G$, $b\ ^2G$, $a\ ^2H$, $b\ ^2H$, 183, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$,
	$t\ ^2G_{5/2}$	39637.83		1.04	$a\ ^4G$, $a\ ^4H$.
$d^3\,sp$ (^{3}G)	$t\ ^4G_{11/2}$	39530.46	355.20	0.61	
	$t\ ^4G_{9/2}$	39885.66	536.27	1.085	$b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$, $a\ ^6D$, $a\ ^2P$, $a\ ^2D$, $a\ ^2F$,
	$t\ ^4G_{7/2}$	40421.93	60.93	1.228	$a\ ^2G$, $a\ ^2H$, $b\ ^2H$, 183.
	$t\ ^4G_{5/2}$	40481.90		1.18	
$d^4\,p$ (^{1}I)	$v\ ^2H_{11/2}$	39845.51	157.49		$a\ ^2F$, $a\ ^2G$, $b\ ^2G$, $a\ ^2H$, $b\ ^2H$, 183, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$,
	$v\ ^2H_{9/2}$	40003.00		1.152	$a\ ^4H$.
$d^3\,sp$ (^{3}D)	$r\ ^4P_{5/2}$	39981.20	228.52	0.45	
	$r\ ^4F_{3/2}$	40209.72	152.28	0.886	$a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$, $a\ ^6D$,
	$r\ ^4F_{5/2}$	40362.00	491.89	1.129	$a\ ^2P$, $a\ ^2F$, $a\ ^2G$, $b\ ^2G$, $b\ ^2H$.
	$r\ ^4F_{7/2}$	40853.89		1.250	
	$400_{3/2}$	40009.84			$b\ ^4P$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$, $a\ ^2F$, $a\ ^2G$.
$d^3\,sp$ (^{1}F)	$q\ ^2F_{7/2}$	40735.18	−265.47	0.91	$a\ ^2D$, $a\ ^2F$, $a\ ^2G$, $b\ ^2G$, $b\ ^2H$, 183, $a\ ^4P$, $b\ ^4P$, $a\ ^4D$,
	$q\ ^2F_{5/2}$	40469.71		1.17	$b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$.
$d^4\,p$ ($c\ ^3$F)	$s\ ^4D_{7/2}$	----			
	$s\ ^4D_{5/2}$	----			$a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$, $a\ ^2D$,
	$s\ ^4D_{3/2}$	40479.90	479.46	1.29	$a\ ^2F$, $a\ ^2G$, $b\ ^2G$.
	$s\ ^4D_{1/2}$	40953.36		1.367	
$d^3\,sp$ (^{3}H)	$s\ ^4G_{11/2}$	40079.30	475.98	0.929	
	$s\ ^4G_{9/2}$	40555.28	365.87	1.089	$a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$, $a\ ^6D$,
	$s\ ^4G_{7/2}$	40921.15	450.02	1.243	$a\ ^2D$, $a\ ^2F$, $a\ ^2G$, $b\ ^2G$, $a\ ^2H$, $b\ ^2H$.
	$s\ ^4G_{5/2}$	41371.17		1.25	

TABLE 6.—*Terms of the* Cb I *spectrum*—Continued

Electron configuration	Term symbol	Level	Difference	Observed g	Combinations
$d\,sp$ (^1D)	$w\ ^2P_{1/2}$	-----			
	$w\ ^2P_{3/2}$	*41082.24*		1.38	$a\ ^2P$, $a\ ^2D$, $a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4G$.
	$411\frac{1}{2}_{3/2}$	*41139.95*		0.88	$a\ ^4P$, $b\ ^4D$, $a\ ^4F$, $a\ ^4G$, $a\ ^2D$, $a\ ^2F$, $a\ ^2G$, $b\ ^2G$, $a\ ^2H$, $b\ ^2H$, $a\ ^4D$.
	$414\frac{1}{2}_{3/2}$	*41460.97*		1.42	$a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^2D$, $a\ ^2F$.
	$416\frac{1}{2}_{5/2}$	*41615.40*			$a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$, $a\ ^2F$, $b\ ^2G$.
	$q\ ^4F_{1/2}$	*41554.86*	191.48	0.556	
	$q\ ^4F_{3/2}$	*41746.34*	184.53	1.25	$a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$, $a\ ^2P$, $a\ ^2D$, $a\ ^2F$, $a\ ^2G$, $b\ ^2G$, $a\ ^2H$, $b\ ^2H$.
	$q\ ^4F_{5/2}$	*41930.87*	−56.96	1.186	
	$q\ ^4F_{7/2}$	*41873.91*			
$d\,p$ (^2G)	$s\ ^2G_{7/2}$	*41571.61*	324.06		$a\ ^2D$, $a\ ^2F$, $b\ ^2G$, $a\ ^2H$, $b\ ^2H$, 183, $b\ ^4D$, $a\ ^4F$, $a\ ^4H$.
	$s\ ^2G_{9/2}$	*41895.67*			
$d\,p$ (^1F)	$p\ ^2F_{5/2}$	*41829.11*	158.24	0.86	$a\ ^2P$, $a\ ^2D$, $a\ ^2F$, $a\ ^2G$, $b\ ^2G$, $a\ ^2H$, $b\ ^2H$, $b\ ^4D$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$.
	$p\ ^2F_{7/2}$	*41987.35*		1.135	
$d\,p$ (^2F)	$r\ ^2G_{7/2}$	-----			
	$r\ ^2G_{9/2}$	*42193.70*		1.15	$a\ ^2F$, $a\ ^2G$, $b\ ^2G$, $a\ ^2H$, $b\ ^2H$, 183, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$.
$d\,sp$ ($b\ ^3P$)	$r\ ^4D_{1/2}$	*41676.81*			
	$r\ ^4D_{3/2}$	*42339.56*	662.75		
	$r\ ^4D_{5/2}$	*42551.56*	212.00	1.45	$a\ ^4P$, $b\ ^4P$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^2P$, $a\ ^2D$.
	$r\ ^4D_{7/2}$	*42719.18*	167.62	1.39	
	$s\ ^2D_{3/2}$	-----			
	$s\ ^2D_{5/2}$	*42316.90*		1.21	$a\ ^2P$, $a\ ^2D$, $a\ ^2F$, $b\ ^2H$, $b\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4D$.
$d\,sp$ (^3P)	$q\ ^4D_{1/2}$	*42324.31*	148.90		
	$q\ ^4D_{3/2}$	*42473.21*	169.69		$a\ ^4P$, $b\ ^4P$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4D$, $a\ ^2P$, $b\ ^2G$, $b\ ^2H$.
	$q\ ^4D_{5/2}$	*42642.90*	089.76		
	$q\ ^4D_{7/2}$	*43332.66*			
$d\,sp$ (^3D)	$p\ ^4D_{1/2}$	*42801.67*			
	$p\ ^4D_{3/2}$	*42900.07*	98.40		
	$p\ ^4D_{5/2}$	*43187.00*	286.93		$a\ ^4P$, $b\ ^4P$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4D$, $a\ ^2D$, $a\ ^2F$, $a\ ^2G$, $b\ ^2G$.
	$p\ ^4D_{7/2}$	*43414.44*	227.44		
$d\,sp$ (^3D)	$o\ ^2F_{5/2}$	*43883.84*			$a\ ^2P$, $a\ ^2D$, $a\ ^2G$, $a\ ^4F$, $a\ ^4G$.
	$o\ ^2F_{7/2}$	-----			
$d\,sp$ ($d\ ^3F$)	$p\ ^4F_{3/2}$	*43894.24*	128.36		
	$p\ ^4F_{5/2}$	*44022.60*	150.40		$a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4H$, $a\ ^4D$, $a\ ^2G$, $a\ ^2H$.
	$p\ ^4F_{7/2}$	*44173.00*	222.80	1.22	
	$p\ ^4F_{9/2}$	*44395.80*		1.28	
$d\,sp$ ($d\ ^3F$)	$n\ ^2F_{5/2}$	*43342.88*	212.29		$a\ ^2D$, $a\ ^2F$, $a\ ^2G$, $b\ ^2G$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^4D$.
	$n\ ^2F_{7/2}$	*43555.17*			
	$q\ ^2G_{7/2}$	*43880.22*			$a\ ^2G$, $a\ ^2H$, $a\ ^4F$, $a\ ^4G$.
	$q\ ^2G_{9/2}$	-----			
$d\,sp$ (^3D)	$v\ ^2P_{1/2}$	*46004.29*	−1940.80	1.27	$a\ ^2P$, $a\ ^2D$, $a\ ^4P$, $b\ ^4P$, $b\ ^4D$, $a\ ^4F$.
	$v\ ^2P_{3/2}$	*44063.49*			
	$o\ ^4D_{1/2}$	-----			
	$o\ ^4D_{3/2}$	*44939.08*			
	$o\ ^4D_{5/2}$	*44906.54*	−33.54		$a\ ^4P$, $b\ ^4P$, $a\ ^4F$, $b\ ^4F$, $a\ ^2D$, $a\ ^2F$, $a\ ^2G$, $b\ ^2G$, $b\ ^2H$
	$o\ ^4D_{7/2}$	*45170.90*	265.36		
$d^2\,sp$ (^3G)	$u\ ^3H_{5/2}$	*45110.13*	148.90	1.09	$a\ ^2F$, $a\ ^2G$, $b\ ^2G$, $a\ ^2H$, $b\ ^2H$, 183, $a\ ^4F$, $a\ ^4G$.
	$u\ ^3H_{6/2}$	*45259.03*			
$d^2\,p$ ($c\ ^2F$)	$m\ ^2F_{5/2}$	*45397.30*		0.94	$a\ ^2D$, $a\ ^2F$, $a\ ^2G$, $b\ ^2G$, $b\ ^2H$, $a\ ^4P$, $b\ ^4P$, $b\ ^4D$, $b\ ^4F$.
	$m\ ^2F_{7/2}$	-----			
$d^2\,p$ ($c\ ^3F$)	$p\ ^3G_{3/2}$	*45719.07*	263.49	0.84	$b\ ^2G$, $a\ ^2H$, $b\ ^2H$, $b\ ^4P$, $a\ ^4F$, $b\ ^4F$.
	$p\ ^3G_{4/2}$	*45982.56*			
$d^2\,s.p$ (^3F)	$n\ ^4D_{1/2}$	*45978.84*			
	$n\ ^4D_{3/2}$	*46364.79*	385.95		
	$n\ ^4D_{5/2}$	*46812.58*	447.79		$a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^2G$.
	$n\ ^4D_{7/2}$	*47275.64*	463.06		

TABLE 6.—*Terms of the* Cb I *spectrum*—Continued

Electron configuration	Term symbol	Level	Difference	Observed g	Combinations
$d^5 s.p$ (^{7}F)	$r\ ^6G_{13/2}$	46011.48	459.23		$a\ ^4P$, $b\ ^4P$, $b\ ^4D$, $a\ ^4F$, $a\ ^4G$, $a\ ^4H$, $a\ ^2F$, $a\ ^2G$, $b\ ^2G$, 183.
	$r\ ^6G_{11/2}$	46470.71	253.49		
	$r\ ^6G_{9/2}$	46724.20	356.63		
	$r\ ^6G_{7/2}$	47080.83			
$d^5 s.p$ (^{7}F)	$o\ ^6F_{11/2}$	46170.04	373.52		$a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$, $a\ ^2G$.
	$o\ ^6F_{9/2}$	46543.56	479.22		
	$o\ ^6F_{7/2}$	47022.78	657.81		
	$o\ ^6F_{5/2}$	47680.59			
	$n\ ^6F_{11/2}$	----			$a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $a\ ^4F$, $a\ ^4G$, $a\ ^2G$.
	$n\ ^6F_{9/2}$	46509.80	422.26		
	$n\ ^6F_{7/2}$	46932.06	214.00		
	$n\ ^6F_{5/2}$	47146.06			
	$469b_{5/2}$	46919.48			$a\ ^4P$, $b\ ^4P$, $a\ ^4D$, $b\ ^4D$, $a\ ^4F$, $a\ ^2P$, $a\ ^2D$.
$d^5 sp$ (^{5}H)	$t\ ^5H_{11/2}$	46954.40	200.82	1.00	$a\ ^2F$, $a\ ^2G$, $b\ ^2G$, $a\ ^2H$, $b\ ^2H$, $a\ ^4F$, $a\ ^4G$.
	$t\ ^5H_{9/2}$	47155.22			
	$o\ ^5G_{11/2}$	47588.49	713.95	0.92	$a\ ^2F$, $a\ ^2G$, $b\ ^2G$, $a\ ^2H$, $b\ ^2H$, 183.
	$o\ ^5G_{9/2}$	48242.44		1.10	
	$475b_{9/2}$	47537.67			$a\ ^4P$, $b\ ^4D$, $a\ ^4F$, $b\ ^4F$, $a\ ^4G$.
	$n\ ^5G_{11/2}$	----			$a\ ^2F$, $a\ ^2G$, $a\ ^2H$, 183, $a\ ^4D$.
	$n\ ^5G_{9/2}$	51788.90			

The observed g-values are entered in column 5 of table 6. These may be compared with Landé values by referring to the publication mentioned earlier [17]. The g-sums for the levels originating in the various possible electron configurations are compared with the Landé sums for the same set of levels in table 7. The agreement is very close. Except in the case of the configuration $d^5 s^2$, for which only one level is missing, several levels are missing from each configuration. The remarkable agreement of the sums supports the conclusion that the coupling is closely *LS*, deviations from Landé g's being accounted for by sharing in instances similar to those especially noted above.

TABLE 7.—*Test of g-sum rule for* Cb I

Electron configuration	Sum observed g's	Landé sum
$d^4 s$	39.811	40.000
$d^5 s^2$	19.965	20.000
$d^4 p$	135.279	135.268
$d^5 sp$	136.598	136.582
d^5	1.99	2.000

All observed term combinations are listed in the last column of table 6. These conform to the selection rules for transitions between energy states, any others that were observed being ruled out as fortuitous. As in Cb II and all other complex spectra, a considerable number of permitted transitions is not observed, because of low

transition probability or superposition. The total number of listed term combinations is 1,042, of which 195 are doublet-doublet, 284 quartet-quartet, 18 sextet-sextet, 375 doublet-quartet, 61 quartet-sextet, 31 doublet-sextet, and 78 involving unidentified levels.

3. ELECTRON CONFIGURATIONS, THEORETICAL AND OBSERVED TERMS

The five outer electrons responsible for the chemical properties and optical spectrum of neutral columbium may be grouped in three possible ways to produce the low terms of Cb I, as follows:

$4d^5$: ^{2}D, ^{2}(PDFGH), ^{4}(PF), ^{2}(SDFGI), ^{4}(DG), ^{6}S.

$4d^4\ 5s$: ^{2}(SDG), ^{2,4}(PF), ^{2}(SDFGI), ^{2,4}(PDFGH), ^{4,6}(D).

$4d^3\ 5s^2$: ^{2}D, ^{2}(PDFGH), ^{4}(PF).

Of the $4d^5$ terms only ^{6}S has been found in Cb I. According to theoretical studies by Laporte [18], reasonably precise calculations can be made of the location of the others. The combinations should lie in the long wavelength visible or infrared and may be masked by bands. The ^{6}D term from $4d^4\ 5s$ is the lowest state of Cb I. The quartets have all been found except the relatively high ^{4}P and ^{4}F in the second parentheses above. The doublets from this configuration are very incomplete. The low terms $b\ ^2$G and $b\ ^2$H have been identified, but are the only low terms about which some uncertainty is felt. The combinations are scattered and all Zeeman patterns unresolved. The assigned j's give the largest number of combinations. An alternative possibility is that the unassigned level, 18332.04, $j=5\frac{1}{2}$, belongs to $b\ ^2$H, and that one of levels now assigned to $b\ ^2$G or $b\ ^2$H is part of the missing ^{2}F from $4d^4\ 5s$. The only other possibility for 18332.04 is $^2I_{5\frac{1}{2}}$. These terms must of course come from $4d^4\ 5s$. No other possibility exists, since all terms from $4d^3\ 5s^2$ have been found except ^{2}D listed first in the tabulation above and expected to be relatively high.

The observed Cb I spectrum is almost entirely accounted for by transitions involving the low terms just discussed and intermediate sets arising from $4d^4\ 5p$ and $4d^3\ 5s5p$. The predicted and observed terms from these configurations are displayed in table 8. Although a considerable number of terms, particularly doublets, is still unknown, the remaining unclassified lines are generally scattered and weak. All recent efforts to extend the classification have yielded meager results so that further work has not been deemed profitable. All intermediate odd sextets are known. One of these, $(4d^3\ 5s5p)\ z\ ^6$G°, combines only with a high even term $(4d^3\ 5s\text{-}6s)\ e\ ^6$F, but the combinations are intense and unmistakable with some support from Zeeman effect. Nearly all quartets are known, ^{4}S and ^{4}P terms being hardest to find. In some instances more than the expected number are found, particularly among the ^{4}F and ^{4}G terms. This indicates the appearance of terms from a $6p$ electron. Some of these have been utilized in series calculations as will be shown in the next section.

TABLE 8.—Cb I *predicted and observed terms*

Electron configuration	Limit Cb II	Predicted	Observed
$4d^4\ 5s$	^5D	^6D, ^4D	$a\ ^6D$, $a\ ^4D$
	^3P	^4P, ^2P	$b\ ^4P$, --
	^3D	^4D, ^2D	$b\ ^4D$, --
	^3F	^4F, ^2F	$b\ ^4F$, --
	^3G	^4G, ^2G	$a\ ^4G$, $b\ ^2G$
	^3H	^4H, ^2H	$a\ ^4H$, $b\ ^2H$
	^{1}(SDFGI)	^{2}(SDFGI)	--, --, --, --, --
	^{3}(PF)	^{4}(PF), ^{2}(PF)	--, --, --, --
	^{1}(SDG)	^{2}(SDG)	--, --, --
$4d^3\ 5s^2$		^4P, ^4F	$a\ ^4P$, $a\ ^4F$
		^{2}(PDFGH)	$a\ ^2P$, $a\ ^2D$, $a\ ^2F$, $a\ ^2G$, $a\ ^2H$
		^2D	--
$4d^5$		^6S	$a\ ^6S$
		^{4}(DG), ^{4}(PF)	--, --, --, --
		^{2}(SDFGI)	--, --, --, --, --
		^{2}(PDFGH)	--, --, --, --, --
		^2D	--
$4d^4\ 5p$	^5D	^{6}(PDF), ^{4}(PDF)	$z\ ^6P°$, $x\ ^6D°$, $y\ ^6F°$, $z\ ^4P°$, $y\ ^4D°$, $y\ ^4F°$
	^3P	^{4}(SPD), ^{2}(SPD)	$z\ ^6S°$, --, $w\ ^4D°$, $z\ ^2S°$, --, $z\ ^2D°$
	^3D	^{4}(PDF), ^{2}(PDF)	$w\ ^4P°$, $t\ ^4D°$, $v\ ^4F°$, $x\ ^2P°$, --, $s\ ^2F°$
	^3F	^{4}(DFG), ^{2}(DFG)	$u\ ^4D°$, $x\ ^4F°$, $w\ ^4G°$, $u\ ^2D°$, $r\ ^2F°$, $r\ ^2G°$
	^3G	^{4}(FGH), ^{2}(FGH)	$u\ ^4F°$, $v\ ^4G°$, $x\ ^4H°$, $v\ ^2F°$, $s\ ^2G°$, $y\ ^2H°$
	^3H	^{4}(GHI), ^{2}(GHI)	$y\ ^4G°$, $y\ ^4H°$, $z\ ^4I°$, $z\ ^2G°$, $z\ ^2H°$, $y\ ^2I°$
	^1S	^2S	--
	^1D	^{2}(PDF)	--, --, $y\ ^2F°$
	^1F	^{2}(DFG)	--, $p\ ^2F°$, --
	^1G	^{2}(FGH)	$w\ ^2F°$, --, $z\ ^2H°$
	^1I	^{2}(HIK)	$v\ ^2H°$, --, --
	^3P	^{4}(SPD), ^{2}(SPD)	--, --, --, --, --, --
	^3F	^{4}(DFG), ^{2}(DFG)	$s\ ^4D°$, $t\ ^4F°$, $u\ ^4G°$, $s\ ^2D°$, $m\ ^2F°$, $p\ ^2G°$
	^1S	^2S	--
	^1D	^{2}(PDF)	--, --, --
	^1G	^{2}(FGH)	--, --, --
$4d^3\ 5s\ 5p$	^5P	^{6}(SPD), ^{4}(SPD)	$z\ ^6S°$, $y\ ^6P°$, $y\ ^6D°$, $w\ ^6S°$, $x\ ^4P°$, $q\ ^4D°$
	^3P	^{4}(SPD), ^{2}(SPD)	$y\ ^6S°$, $y\ ^4P°$, $x\ ^4D°$, $y\ ^2S°$, $y\ ^2P°$, --
	^3F	^{6}(DFG), ^{4}(DFG)	$z\ ^6D°$, $z\ ^6F°$, $z\ ^6G°$, $r\ ^4D°$, $w\ ^4F°$, $x\ ^4G°$
	^3F	^{4}(DFG), ^{2}(DFG)	$z\ ^4D°$, $z\ ^4F°$, $z\ ^4G°$, $y\ ^2D°$, $z\ ^2F°$, $y\ ^2G°$
	^3P	^{4}(SPD), ^{2}(SPD)	$x\ ^6S°$, --, $r\ ^4D°$, --, --, $p\ ^2D°$
	^1P	^{2}(SPD)	--, --, $x\ ^2D°$
	^3D	^{4}(PDF), ^{2}(PDF)	--, $p\ ^4D°$, $r\ ^2F°$, $p\ ^2P°$, $t\ ^2D°$, $o\ ^2F°$
	^1D	^{2}(PDF)	$w\ ^2P°$, $w\ ^2D°$, $u\ ^2F°$
	^3F	^{4}(DFG), ^{2}(DFG)	--, $o\ ^4F°$, --, --, $u\ ^2F°$, $t\ ^2G°$
	^1F	^{2}(DFG)	--, $q\ ^2F°$, --
	^3G	^{4}(FGH), ^{2}(FGH)	$s\ ^4F°$, $t\ ^4G°$, $z\ ^4H°$, $t\ ^2F°$, $s\ ^2G°$, $u\ ^2H°$
	^1G	^{2}(FGH)	$x\ ^2F°$, $x\ ^2G°$, $w\ ^2H°$
	^3H	^{4}(GHI), ^{2}(GHI)	$s\ ^4G°$, --, --, $u\ ^2G°$, $t\ ^2H°$, --
	^1H	^{2}(GHI)	$w\ ^2G°$, --, $z\ ^2I°$
	^3D	^{4}(PDF), ^{2}(PDF)	--, --, --, --, --, --
	^1D	^{2}(PDF)	--, --, --

The criteria which have been found useful in assigning the various terms to electron configurations and ionization limits are summarized as follows:

1. *Order or relative position of terms of* Cb II.—These terms constitute the ionization limits for Cb I, and terms correlated with the various limits are expected to be distributed in an analogous manner.

2. *Intensities of multiplet combinations.*—If the ionization limit of the low term is known, and it is certain in all instances in Cb I, the

high term of the combination yielding the strongest line is expected to go to the same limit. In other words, it is in the same family.

3. *The position of analogous terms in vanadium* I.—These spectra closely resemble each other, terms of similar origin appearing at about the same elevation above the lowest.

4. *Assignment to give the best conformity with the g-sum rule.*—This is largely a matter of picking out instances of g-sharing, of which selected examples have been given.

5. *Hyperfine structure.*—The association of the appearance of hyperfine structure with the configuration involving a single s-electron has been discussed earlier in the paper. It is to be noted that the numerous combinations of $a\,^4F$ and $a\,^4P$ from $4d^3\,5s^2$ are relatively sharp.

4. SERIES AND IONIZATION POTENTIAL

Two high even terms have been found in Cb I, of which the first, $4d^4\,6s\,(^5D)\,e\,^6D$, is the second series member associated with $4d^4\,5s\,(^5D)\,a\,^6D$, the lowest state of the atom. This series converges to $a\,^5D$, the lowest state of the ion. The other high term, $4d^3\,5s{\cdot}6s\,e\,^6F$, appears for the first time in this configuration, having no counterpart in the $4d^3\,5s^2$ configuration because of the operation of the Pauli exclusion principle. Attempts to find high even quartets analogous to those known in V I proved futile. A few fragmentary terms, tentatively established, were not considered certain enough to be retained.

Three high odd terms, $n\,^4D°$, $o\,^4F°$, and $r\,^4G°$, all attributed to the configuration $4d^3\,5s6p$, are associated with the lowest odd terms $z\,^4D°$, $z\,^4F°$, and $z\,^4G°$ from $4d^3\,5s5p$, and converge to $4d^3\,5s\,a\,^3F$ in Cb II.

The ionization potential has been calculated both from the even sextet series and from these odd series. In general, four steps are required to calculate the ionization limit or elevation of the lowest state of the ion from the lowest state of the atom for a given set of levels in series when only two members of the series are known. First, the separation of the two members is found by subtracting the relative values. Second, this difference is located as closely as possible in a Rydberg interpolation table [19]. In the column adjoining on the left in the table is found the absolute value of the lower term or distance in wave-number units between this term and its ion limit. Third, the value of the lower term measured from the normal state is added to the number so found to give the elevation of the ion limit above the normal state of the atom. Finally, the value of the limiting term in the ion spectrum relative to its normal state is subtracted, and the remainder gives the required lowest ionization limit. It is converted to electron volts by dividing [20] by 8067. The results of these calculations for the available data are summarized in table 9.

TABLE 9.—Cb I *series*

Term	Electron		n^* for 5*s*	Limit	Cb II	Ionization
	5*s*	6*s*				
a $^6D_{9/2}$	1050	38508	1.3910	57702	1225	56537
a $^6D_{7/2}$	695	38178	1.3915	57363	801	56562
a $^6D_{5/2}$	392	37842	1.3920	57021	438	56582
a $^6D_{3/2}$	154	37579	1.3925	56751	159	56592
a $^6D_{1/2}$	0	37410	1.3927	56579	0	56579
Mean	-----	-----	-------	-----	----	56571

Term	Electron		n^* for 5*p*	Limit	Cb II	Ionization
	5*p*	6*p*				
z $^4D_{5/2}$	21512	47276	1.6216	63242	8320	54922
z $^4D_{3/2}$	20838	46813	1.6163	62844	7901	54944
z $^4D_{1/2}$	20384	46365	1.6161	62399	7506	54893
z $^4D_{-1/2}$	20107	45979	1.6189	61979	7506	54473
Mean	-----	-----	-------	-----	----	54808
z $^4F_{5/2}$	24057	47681	1.6924	62819	8320	54498
z $^4F_{3/2}$	24015	47023	1.6973	62106	7901	54205
z $^4F_{1/2}$	23574	46544	1.6984	61614	7506	54108
z $^4F_{-1/2}$	23244	46170	1.7002	61226	7506	53720
Mean	-----	-----	-------	-----	----	54133
z $^4G_{5/2}$	24203	47081	1.7012	62121	8320	53800
z $^4G_{3/2}$	23537	46724	1.6920	61867	7901	53966
z $^4G_{1/2}$	23023	46471	1.6844	61699	7506	54193
z $^4G_{-1/2}$	22647	46011	1.6868	61212	7506	53707
Mean	-----	-----	-------	-----	----	53916

The mean ionization limit from 5 levels associated with *s*-type electrons is 56,571 cm^{-1}, whereas the mean from 12 levels involving *p*-type electrons is 54,286 cm^{-1}. The difference is probably due to the departure of one or other type of series from the simple Rydberg form. For V I Meggers and Russell [7] discarded this procedure, and calculated the ionization limit from values of the effective quantum number n^* estimated from the spectra of flanking elements, Ti and Cr. Columbium is flanked by Zr and Mo, for which the effective quantum numbers of terms with highest multiplicity associated with 5*s* are 1.47 and 1.36, respectively [21]. The value thus indicated for Cb I is 1.41, corresponding to a term value of

$$T=(R/n^{*2})=109737/1.41^2=54{,}868\ cm^{-1}$$

for *a* $^6D_{0\frac{1}{2}}$. This is in close agreement with the ionization value 54,286 cm^{-1} derived from the odd quartet terms. We consider a rounded mean of 54,600 cm^{-1} will represent the ionization value of Cb I with fair accuracy—it corresponds to a principal ionization potential of 6.77 volts.

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WASHINGTON, June 17, 1944.

U. S. Department of Commerce National Bureau of Standards

RESEARCH PAPER RP1657

Part of Journal of Research of the National Bureau of Standards, Volume 34, June 1945

DIAMOND CUTTING ACCELERATED BY AN ELECTRIC ARC

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ABSTRACT

The method universally employed for cutting plane surfaces or facets on diamonds has been to place the diamond in contact with a flat cast-iron lap charged with diamond powder and rotated at about 2,000 revolutions per minute. In the work described in this paper it was found that by producing a high-voltage electric arc at the contact between the diamond and the lap, the cutting rate is materially increased for all orientations of the diamond, and good progress can be made directly on a natural octahedron face, where cutting without the arc is almost impossible.

By applying the arc to a diamond saw the sawing rate is greatly increased, and diamonds can be sawed regardless of the orientation of the cut relative to the crystal axes.

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I. INTRODUCTION

In cutting surfaces on precision diamond tools required in research developments of standards of length, microhardness testing, methods for producing diamond dies, jewel bearings, etc., at the National Bureau of Standards, it was found that the rate of cutting was greatly increased by producing a high-voltage electric arc at the contact between the diamond and the surface of a rotating lap charged with diamond powder. The cutting method universally employed by the lapidaries since the beginning of the art [1, 2] has been to spin a flat cast-iron lap about 1 foot in diameter at approximately 2,000 revolutions per minute. Diamond powder mixed with olive oil or some other viscous material is fed onto the surface of the lap. The diamond is embedded in a wiping solder contained in a copper cup or dop, which in turn is supported by a wooden arm. The diamond is brought into

contact with the surface of the spinning lap and cut until the desired surface, or facet, is produced.

Diamonds crystallize in the cubic system, which has three equal axes at right angles, in the form of octahedrons, dodecahedrons, and cubes [1, 3]. It is well known that a facet can be most readily cut when it has certain orientations relative to the crystal axes. As a general rule, cutting is most rapid when the facet is parallel to one or two of the axes and the direction of motion of the lap surface is parallel to one of the axes. It is well established that cutting on an octahedron face, which is approximately at a 35-degree angle to all three axes, is almost impossible.

The fact that under certain orientations the diamond is more resistant to abrasion than under others no doubt makes it possible to cut a diamond with its own powder. A part of the myriad of fine particles in the powder is always in the most resistant position and will abrade a surface oriented in a less resistant plane.

While making microhardness tests of diamonds from various sources, it was possible to make as many as 50 indentations, 30 microns long, in the flat surface of a diamond without injury to the point of a diamond indenter cut in the form of a four-sided pyramid. This led to the conclusion that the indenter point under compression had greater resistance to fracture than the diamond surface under tension. This may supply another explanation for the ability of powder particles to fracture or abrade the facet.

By applying the electric arc to diamond-cutting machines in general use, as described in this paper, good progress can be made when cutting is done in any direction directly on the octahedron face, and the rate of cutting on any surface can be closely controlled by adjusting the primary current.

II. METHOD AND APPARATUS

The diamond cutting apparatus developed at this Bureau is shown in figure 1, and the wiring diagram is given in figure 2. The lap, *L*, of cast iron, copper, or other material supported by the base, *W*, is driven by the motor, *M*, at speeds ranging from 30 to 2,500 revolutions per minute. An arm, *B*, of insulating material such as 1-inch-square fiber bar, supports the diamond, *D*, and the weight, *F*.

The leads from the 110-volt, 60-cycle alternating-current outlet are connected to the primary terminals of a 5,000-volt, 50/1, 300-volt-ampere power transformer, *T*. In one of the primary connecting leads a variable rheostat, *P*, of 400 ohms is placed and in the other an alternating-current ammeter, *A*, of 2-ampere range. A capacitor, *C*, of about 0.001 to 0.008 microfarad is connected across the secondary leads of the transformer. The rheostat may be dispensed with if a current-limiting transformer, such as a 12,000-volt, 20-milliampere neon sign lighting transformer is used instead of the power transformer and a 0 to 120-volt output Variac is placed between the alternating-current outlet and the transformer.

One of the secondary leads of the transformer is connected to *F* and the other to a brush, *E*, which makes electric contact with the bottom of lap, *L*. The diamond is mounted in a copper dop, high melting

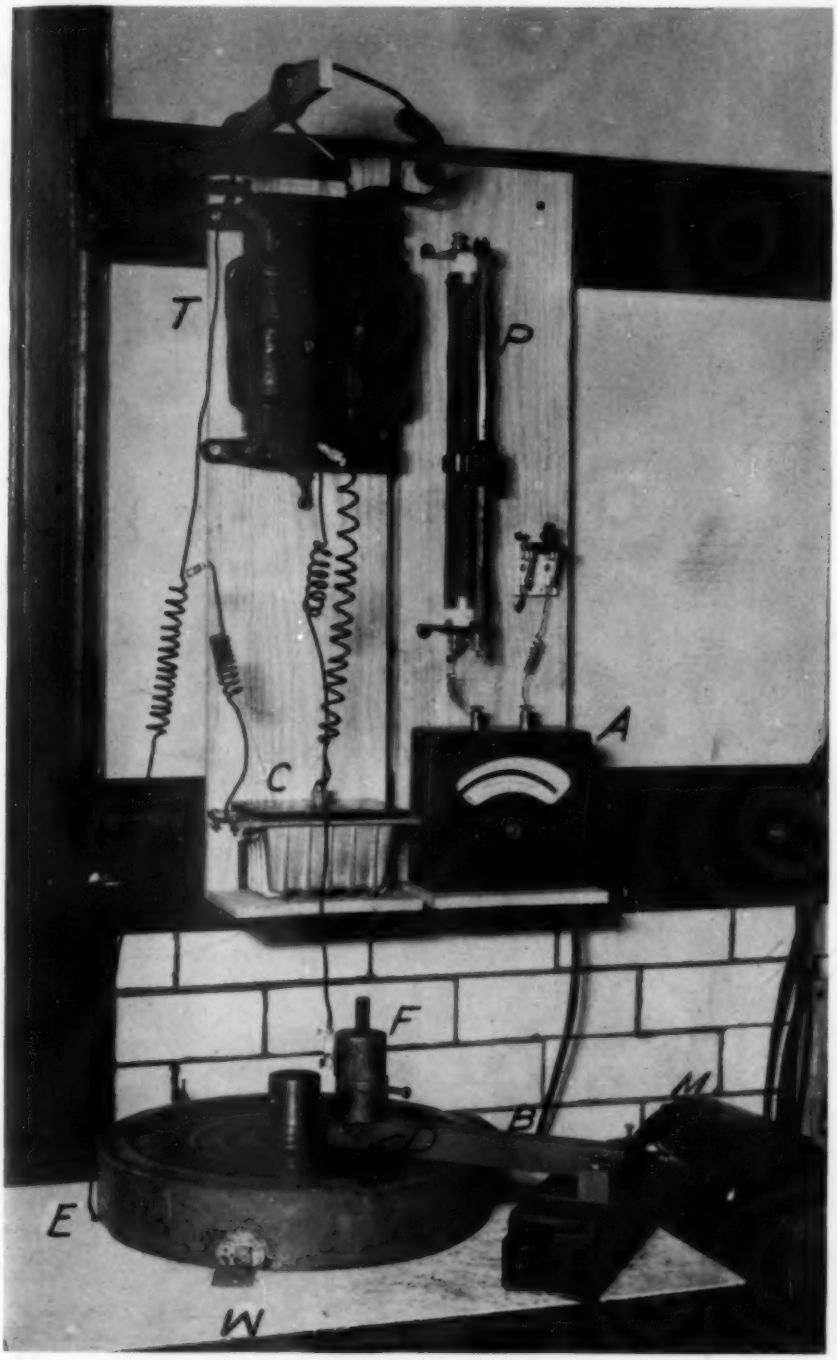

FIGURE 1.—*Diamond lap with electric equipment and connections.*

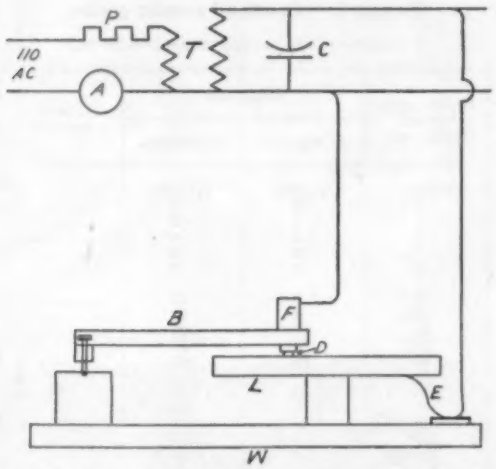

FIGURE 2.—*Wiring diagram for apparatus shown in figure 1.*

point solder being used, such as SAE No. E06, tin, lead, silver, or an alloy of equal weights of silver and aluminum and protrudes about ½ to 1 millimeter from the surface of the surrounding solder. The heat conductivity of the copper reduces the chance of solder being melted by the frictional heat of the lap.

III. PREPARATION OF THE LAP

A cast-iron lap of high carbon and graphite content and containing numerous small pits or pockets is turned in a lathe on both sides and on the edge and carefully balanced. It was found that cross scoring of the top surface of the lap by hand or with a cupped wheel was not necessary, but the final cut should be light to produce a smooth surface. A small quantity of diamond powder and a few drops of oil are applied to the lap, mixed well and rubbed into the surface with a flat, hardened steel block. A mixture of oil and powder can be applied while the lap is in motion, but this is rather wasteful of powder.

IV. CONTROL OF CUTTING RATE

1. DIAMOND POWDER

In a recent report on diamond powder prepared by the National Bureau of Standards for the War Production Board, N. R. C. 535, Serial No. W–144, grade specifications for diamond powder were proposed. With the cooperation of the diamond industry, the Trade Standards Division of this Bureau has prepared the following specifications for standard grades, which when adopted should result in uniform grade designation.

For diamond cutting, grades 25 and 40 were found to give good results. Grade 40 cut slightly faster than grade 25, but the latter produced a better finish.

TABLE 1.—*Diamond powder grades*

[1 micron=0.00004 in.; 25.4 microns=0.001 in.]

Grade number and average size	Grain size		Sieve number
	Minimum	Maximum	
Microns	*Microns*	*Microns*	
1	0	2	----------
2	1	3	----------
3	1	5	----------
3x	0	6	----------
6	4	8	----------
8	6	10	----------
8x	4	12	----------
14	8	20	----------
25	13	37	----------
40	20	60	325
60	35	85	230
90	60	120	170
120	80	160	120
150	100	200	100
180	120	240	80
250	150	350	60
400	250	550	40

2. MIXING OIL

Experiments were run, a number of different oils being used for mixing with the diamond powder. Vegetable oils such as olive oil and also asphalt-base mineral oils burned off rapidly from the heat of the arc. The best results were obtained with paraffine base, high flash point Pennsylvania oils of 30 to 50 SAE viscosity number.

3. LAP SPEED

The lap was revolved at various speeds between 30 and 2,500 revolutions per minute. At the lower speeds the cutting rate was almost as fast as at the higher speeds, but the surface of the diamond showed a ground appearance. Speeds near 2,000 revolutions per minute gave good cutting rate and surface finish. At the low speeds the dop remained cool; therefore, the heat of the arc, although sufficient to account for most of the burning away of the oils at the contact surface, had negligible effect on the dop and solder. Almost all the heat transmitted to those elements must be produced by the friction between the diamond and high speed lap.

4. ELECTRIC CONDITIONS

Returning to figures 1 and 2, the maximum cutting rate was attained with an applied voltage of 110 volts, a current of about 0.5 ampere in the primary of 50/1 transformer, T, and a capacitance across the secondary leads of 0.005 to 0.008 microfarad. To obtain that current in the primary circuit the rheostat, P, was adjusted to about 200 ohms. To decrease the cutting rate, the primary current and the capacitance were reduced.

Increased current augmented the arc, which in turn produced increased burning of the mixing oil and a slower cutting rate.

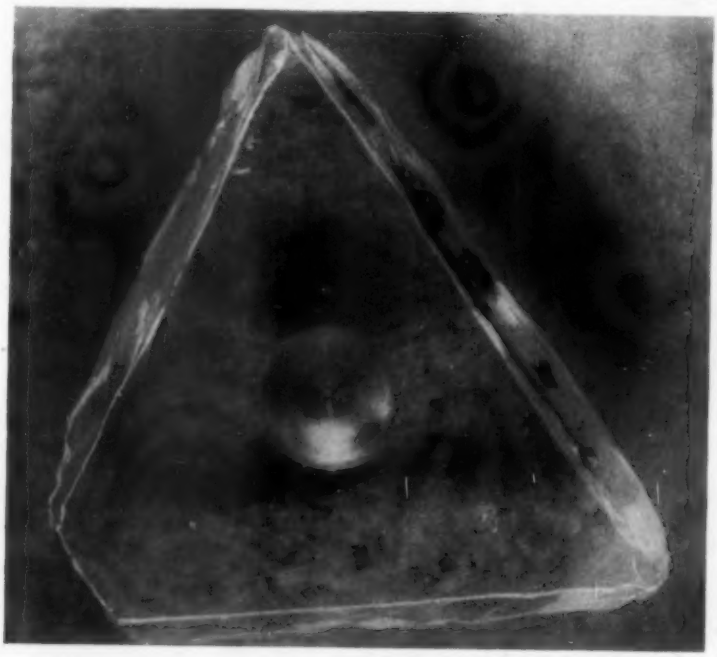

FIGURE 3.—*Facet cut on the octahedron face of a diamond.*

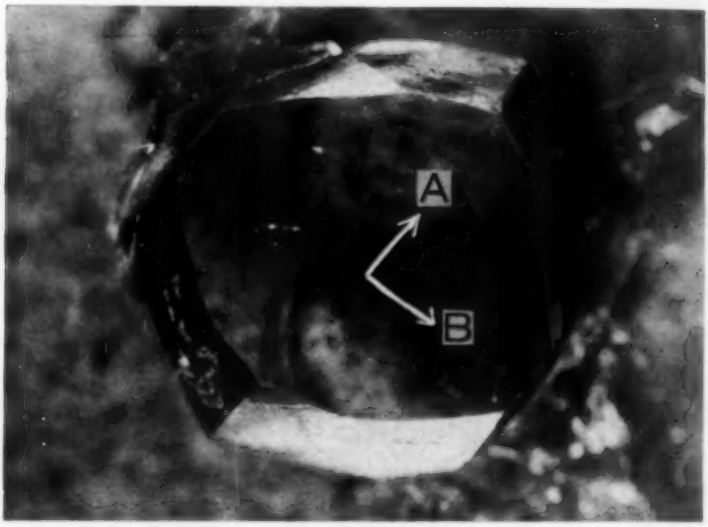

FIGURE 4.—*Facet cut on the dodecahedron face of a diamond.*
Direction *A*, parallel to one axis; direction *B*, perpendicular to one axis.

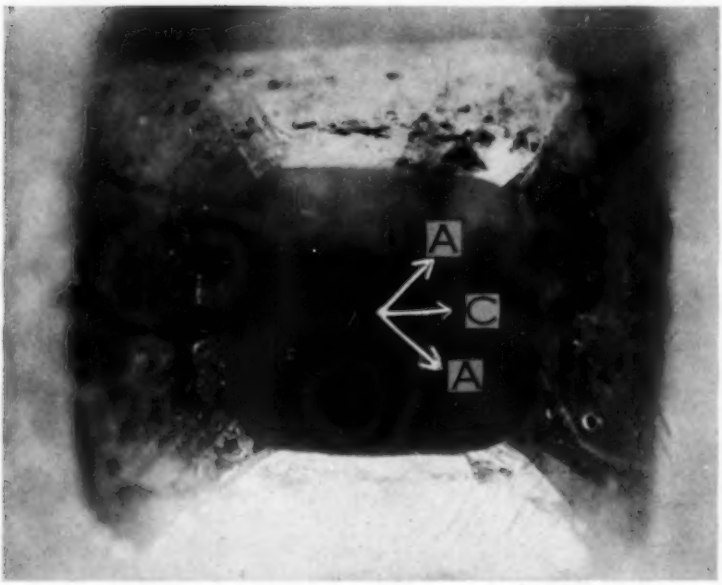

FIGURE 5.—*Facet cut on cube face of a diamond.*
Direction *A*, parallel to one axis; direction *C*, 45 degrees to two axes.

V. TEST OF CUTTING RATE

To determine the effect of the electric arc on the cutting rate, experiments were run on some 25 different diamond crystals, including octahedrons, cubes, dodecahedrons, three-point, capes and macles.

Several well-formed diamond crystals were especially prepared by cutting a base and table accurately parallel to one another. The distances between these two facets before and after making the test cuts were carefully measured with a micrometer. The tables were cut to an area of about 8 square millimeters, 0.013 square inch, before the rate data were recorded. Thereafter, the time required to remove an additional thickness of from 0.010 inch to 0.040 inch was used to determine the cutting rate, which is taken as the time required to remove a layer of 0.001-inch thickness from a facet of about 8 square millimeters, 0.013-square-inch area. Test cuts were also made on the back faces of diamond dies, figure 3. The thickness removed was accurately determined by means of a micrometer microscope sighted through the die window.

The base and table in each case were cut accurately parallel to one of the principal crystal faces of the diamond. Figure 3 shows the facets cut parallel to the octahedron face, which makes angles of 35 degrees with the three crystal axes. Figure 4 shows the facets cut parallel to a dodecahedron face, which is parallel to one axis and makes angles of 45 degrees with the other two axes. Figure 5 shows the facets cut parallel to the cube face, which is parallel to two axes and perpendicular to the third.

On the octahedron face the rate of cutting was the same for all directions of motion of the lap surface. On the dodecahedron face the maximum cutting rate resulted when the direction of the lap motion was parallel to the crystal axis shown by *A* in figure 4, and the rate was at a minumum at 90 degrees to that direction as shown by *B*. For the cube face, the cutting rate was at a maximum when the lap direction was parallel to one of the two axes as shown by *A* in figure 5 and at a minimum at 45 degrees to those directions as represented by *C*. For intermediate directions the cutting rate lies between these extremes. In table 2 are given the maximum and minimum cutting rates, as defined above, with and without the arc, for diamonds cut on the three crystal faces. For like conditions of crystals face and lap direction there was but little variation of rate between individual diamonds.

TABLE 2.—*Comparison of cutting rates*

	Time in minutes	
	Without arc	With arc
Dodecahedron face (fig. 4):		
Lap direction *A*	5.3	4.8
Lap direction *B*	255.0	63.0
Cube face (fig. 5):		
Lap direction *A*	15.0	9.2
Lap direction *C*	110.0	45.0
Octahedron face (fig. 3):		
Three-point cape and macle	>5,000	62.0
Regular octahedron	>5,000	39.0

From these data it is seen that when cutting is done on the dodecahedron face with the lap direction parallel to the axis, *A*, (which appears to be the most favorable condition for cutting diamonds), the rate is about the same with or without the arc. With the lap direction at right angles to the axis, *B*, however, the arc increases the cutting rate about four times.

On the cube face, when the cutting was parallel to one axis and at right angles to the other, *A*, figure 5, the arc doubled the rate, and at 45 degrees to the two axes, *C*, it increased the rate by about two and one-half times.

For the octahedron faces without the arc, no cutting resulted in any direction of the lap motion; that is, not as much as 0.0001 inch layer could be removed in a day's time. This agrees with the experience of expert lapidaries, as recorded in the literature [2, 4].

With the arc, however, the cutting rate on the octahedron face equals the rates found for the unfavorable directions on the cube and dodecahedron faces, which in turn have been augmented about four times by the use of the arc. That the arc facilitates such rapid cutting directly on the octahedron face is the most striking result of this work. This should make it possible, in designing industrial diamond tools, to take full advantage of the orientation of the crystallographic directions of the diamond with respect to the cutting surface of the tool [5].

The data presented here have been obtained from facets cut parallel to the three principal crystal faces. Additional quantitative cutting-rate data are being accumulated for other definite orientations of the facets.

VI. TEST OF SAWING

Sawing diamonds by established methods can only be performed in certain directions parallel to either a cube or dodecahedron face and have been called the "sawing grain." According to Grodzinsky, "It is almost impossible to saw the diamond in other directions even if they differ a few degrees from the original axis" [2, p. 44]. It should be added that when sawing parallel to the cube or dodecahedron face the direction of motion of the saw edge should be nearly parallel to one of the crystal axes.

To test the effect of the arc when applied to diamond sawing, a saw previously employed for slicing sapphire and spinel during an investigation of jewel bearing materials was employed. This machine, which has a phosphor bronze disk 6 inches in diameter and 0.012 inch thick rotating at about 2,800 revolutions per minute, cannot be considered efficient for sawing diamonds. The diamond was mounted in an insulated metal block, which was connected to one secondary terminal of the transformer and the disk was connected to the other terminal. With the aid of the arc, which is formed at the contact of the diamond and saw edge, the diamond can be sawed regardless of the axial orientation.

The relative sawing rates for different directions agree with those found for similar directions when cutting was done with the flat lap. Sawing directly on the octahedron face of the diamond in figure 3, with the direction of motion of the saw edge parallel to the face, a cut 0.14 inch long, 0.015 inch wide, and 0.017 inch deep was produced in 75 minutes. Sawing on the dodecahedron face of the diamond

in figure 4 with the direction of motion of the edge of the saw parallel to the crystal axis, that is, in direction A, a cut 0.14 inch long, 0.020 inch wide, and 0.030 inch deep was made in 15 minutes.

When sawing at right angles to the crystal axis or in direction B, figure 4, the sawing rate was about the same as for the octahedron face.

If we define the cutting or sawing direction as the direction of motion of the diamond particles imbedded in the lap or the edge of the saw, the maximum cutting rate results when that cutting direction is parallel to one of the crystal axes. Under this condition the cutting direction makes angles of from about 35 to 45 degrees with the octahedron faces or clevage planes. When the cutting direction is parallel to the octahedron faces or clevage planes the cutting rate is at a minimum. For other orientation the cutting, or sawing, rate lies between these two extremes. These same rules should hold for the rate of wear in diamond dies.

Experiments are now in progress the purpose of which is to find the explanation of the electric phenomena involved in the arc cutting, sawing, and drilling of diamonds. However, the data now accumulated do not justify definite conclusions regarding the nature of the process.

VII. SUMMARY

By connecting the lap of a diamond cutting machine to one of the secondary terminals of a 5,000-volt power transformer having a current of about 0.5 ampere flowing through the primary circuit and the dop to the other terminal, a bluish arc is produced at the contact of the diamond and lap. Under these conditions the cutting rate is materially increased for all orientations of the facets relative to the crystal axes of the diamond. Good progress can be made directly on the octahedron faces, where no appreciable cutting could be effected by the methods generally employed. Similarly, by applying the arc to the diamond saw the sawing rate is greatly increased and cuts can be made in the diamond under any orientation.

VIII. REFERENCES

[1] Kraus and Slawson, Gems and gem materials, fourth edition (McGraw-Hill Book Co., Inc., New York, N. Y. and London, 1941).
[2] Paul Grodzinski, Diamonds and gem stones—industrial production, first edition (N. A. G. Press, Ltd., London, and Henry Paulson & Co., 37 S. Wabash Ave., Chicago, Ill., 1942).
[3] Dana's textbook of mineralogy, p. 70, fourth edition (John Wiley & Sons, Inc., New York, N. Y. and Chapman & Hall, Ltd., London, 1932).
[4] Kraus and Slawson, American Mineral. **24,** 661 (November 1939).
[5] Kraus and Slawson, American Mineral. **26,** 153 (1941).

WASHINGTON, March 30, 1945.

U. S. Department of Commerce National Bureau of Standards

RESEARCH PAPER RP1658

Part of Journal of Research of the National Bureau of Standards, Volume 34, June 1945

A TRANSFER STRAIN GAGE FOR LARGE STRAINS

By Martin Greenspan and Leroy R. Sweetman

ABSTRACT

A simple strain gage, suitable for measurement of strains of from −16 to +32 percent on a 1.5-inch gage length, is described.

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I. GENERAL

A simple and inexpensive strain gage, having a range of −16 to +32 percent on a 1.5-inch gage length, has been devised and successfully used at the National Bureau of Standards for the determination of the stress-strain relations in the plastic range of some aluminum alloys and steels.

The gage consists of two distinct steel blocks equipped with steel knife edges (or conical points) which are kept in contact one with each end of the gage line by means of spring clips. The blocks move in relation to each other when the length of the gage line changes, but are kept in alinement by means of a rod attached to one block passing through a hole in the other. One block, (the indenter block), carries a hardened steel indenter mounted on a cantilever leaf spring; the other block, (the target block), has cemented to it, before the test, a brass target. The gage is operated by depressing the spring manually so that the indenter leaves a small mark on the target; a record of the deformations of the gage line corresponding to the various loads is thus transferred to and preserved on the target, from which it is read after the test is completed by means of a travelling micrometer microscope.

II. CONSTRUCTION

The gage is shown in figure 1. The alinement rod, *a*, is a piece of ⅛-inch-diameter drill rod pressed into a hole in the indenter block, *b*. The guide hole in the target block, *c*, which engages the alinement rod, is subdrilled and reamed to size. Although the clearance between the alinement rod and the guide hole is very small, it is large enough to allow the blocks to tilt with respect to each other and affect the accuracy of the gage. For this reason the alinement rod is provided

along its entire length with a flat about 0.08 inch wide, against which bears a flat-end setscrew, *d*, seated in the shoulder of the target block. By means of this setscrew the clearance is adjusted to the smallest value that will not cause binding.

The knife edge, *e*, which has an included angle of 60 degrees is made from ⅛-inch drill rod, hardened. The shank presses into a 1.8-mm-diameter hole in the block. The faces are ground and then lapped in a small indexing grinder constructed for the purpose.

The indenter (not visible in fig. 1) is made from ⅛-inch square drill rod, hardened. The striking face is in the form of a square pyramid, with an included angle of 120 degrees between opposite faces. The intersections of the two pairs of opposite faces are slightly offset, so that the extreme tip of the pyramid is not a point, but a line 0.002 to 0.003 inch long. An end-on view of an indenter is given in figure 2. The faces of the indenter are ground and lapped in the same indexing grinder as the knife edges.

The indenter is provided with an 0–80 threaded shank which passess through a hole in the ¼ by 0.006-inch spring-steel leaf, *f* (fig. 1), and is secured by a nut, *g*. A 2–56 steel machine screw, *h*, secures the spring to the indenter block.

The brass target, *i*, is a piece of ⅛-inch square brass rod ¾ inch long. Each target is used for four tests. Before use, one surface of the target is polished on abrasive paper to remove the major surface imperfections. The target is then cemented to the target block so that the polished surface is uppermost and one end of the target is in contact with the shoulder of the target block. This position of the target gives a range of almost 0.5 inch in tension and almost 0.25 inch in compression if the initial gage length is 1.5 inch Shellac is a convenient adhesive; it dries sufficiently well in a few minutes, and the target can be detached from the block by hand when the test is completed.

III. OPERATION

Fine scratches are scribed at the ends of the gage line on the specimen and the knife edges of the gage are set in the scratches. The gage is held by spring clips as shown in figure 3. The indentations are made by pressing with a finger the nut which holds the indenter. A light touch, such as produces indentations 0.0003 to 0.0005 inch wide is best from the standpoint of legibility. The photomicrograph, figure 4, shows part of a record obtained in a test.

IV. ACCURACY

The record may be read by means of any suitable measuring microscope. A Zeiss travelling microscope at 56 magnification, accurate to about 0.00015 inch has been used for all the tests thus far made with these gages.

The microscope is focussed on the botton of the indentation which appears as a sharp line. These lines are not visible in figure 4, but they would appear as vertical lines bisecting, approximately, the indentations.

The six gages that have been used at the Bureau were calibrated against standard gage blocks in the extensometer comparator [1] of

[1] Ambrose H. Stang and Leroy R. Sweetman, An extensometer comparator, J. Research NBS 15, 199 (1935) RP822.

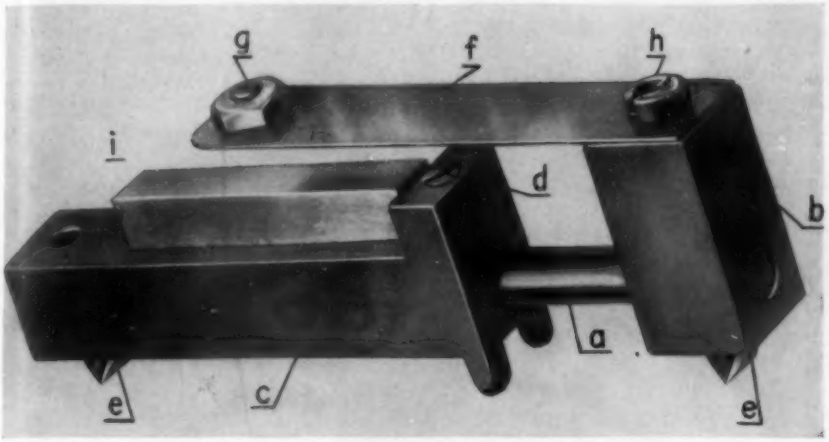

FIGURE 1.—*Transfer strain gage,* 2×.
The gage weighs about ½ ounce.

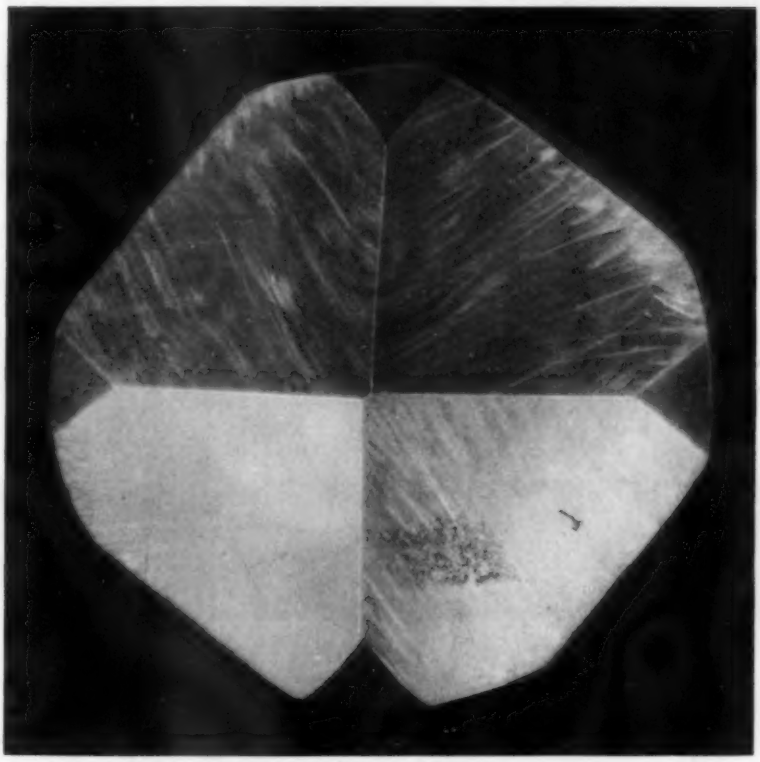

FIGURE 2.—*Indenter, end-on view,* 25×.

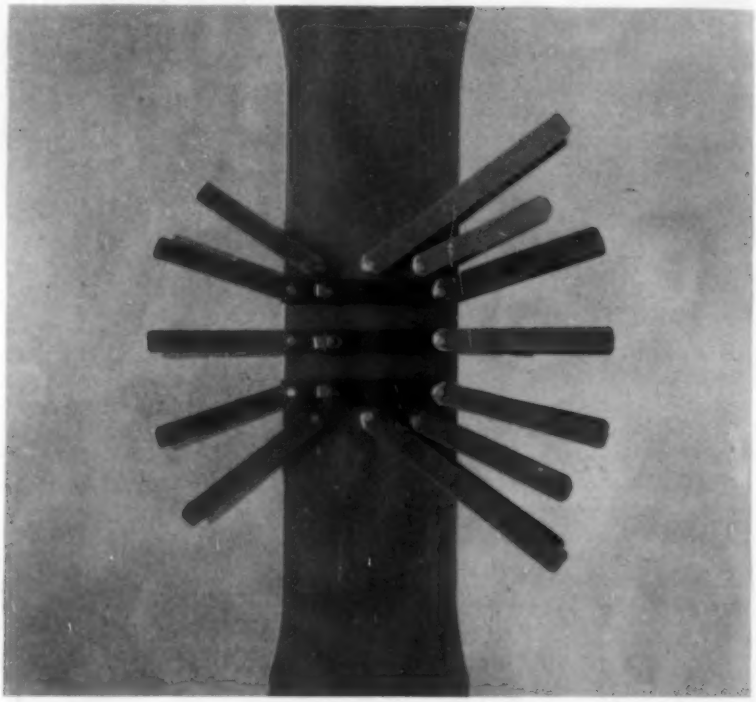

FIGURE 3.—*Three transfer gages in place transverse to the axis of a tensile-test specimen of aluminum alloy.*

Three additional gages, parallel to the axis of the specimen, are on the other side.

FIGURE 4.—*Part of a record obtained in a tension test, 80×.*

Stang and Sweetman. Three of these gages exhibited only random errors of the same order of magnitude as the errors in the micrometer screw of the microscope. The other three gages were affected by an additional systematic error not exceeding 0.2 percent. This systematic error is probably a result of the relative tilt of the blocks produced by the take-up, during separation of the blocks, of the clearance between the alinement rod and guide hole.

During a test, conditions for the production of legible, uniform indentations are not as favorable as during a calibration, especially if more than one gage is to be operated simultaneously by one operator. However, it is felt that the gages can be relied upon to measure extensions within perhaps 0.4 percent plus 0.0002 inch. Thus on a 1.5-inch gage length, strains greater than 2 percent may be measured with an error of less than 1 percent.

WASHINGTON, April 3, 1945.

U. S. Department of Commerce National Bureau of Standards

RESEARCH PAPER RP1659

Part of Journal of Research of the National Bureau of Standards, Volume 34, June 1945

REFRACTIVE-INDEX STANDARDS OF FLUORCROWN GLASS

By Leroy W. Tilton

ABSTRACT

Refractive-index samples of fluorcrown glass, which provide solid standards in the index range between fused quartz, n_D=1.458, and low index silicate crown glass, n_D=1.51, are characterized by very low temperature coefficients of index, and thus are especially recommended for use at extreme room temperatures. The calibration of such standards may be facilitated by comparisons with the precise data herein tabulated for six of these glasses in the temperature range 15° to 55° C. Because of surface weathering, repolishings are sometimes necessary to avoid hazy and possibly false critical border lines. In some cases bright bands appear in the dark portion of the refractometer field. These are interpreted as critical-angle phenomena corresponding to decomposition products in the surface layers.

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I. INTRODUCTION

The refractive-index range 1.45 to 1.50, in which comparatively few solid standards are available, is important on the scales of commercial refractometers because so many oils, fats, and other liquids are included. Although this interval is relatively small on instruments of the Abbe type, it includes a large and much-used portion of the Butyro refractometer scale and all modern dipping refractometers with detachable prisms provide adequately for index measurements within this range.

The makers of refractometers usually supply only one test slab or test specimen to be used in adjusting a given refractometer. For the Abbe type, with its wide index range, a piece of optical crown glass with index at least as high as 1.5 is customarily supplied, and on the Butyro type the scale extends so low that fluorite can be used for adjustments if one is not satisfied with the fluid that is sometimes furnished. The immersion refractometers can cover this index range with two of the interchangeable prisms so designed that one is adjusted at the lower end of its scale by means of fluorite and the other prism adjusted at the upper end of its scale by a piece of borosilicate crown glass with low index.

In order, however, that anyone may adequately check the accuracy of a Butyro scale, or the corresponding prisms of an immersion refractometer, it is highly desirable to have a number of standard test specimens in this much-used range of 1.45 to 1.50 in refractive index. For such purposes solid standards are preferable to liquids because of their lower temperature coefficients of refractivity and relatively greater permanence, stability, and freedom from contamination. Since, moreover, there has been no satisfactory specification of the exact conditions under which liquid and solid standards may be used interchangeably, fluorcrown glasses are desirable for research purposes in precise refractometry.

II. DESCRIPTION OF PRISMATIC STANDARDS

In the refractometric laboratory at this Bureau, 13 refractive-index standards of fluorcrown glass have been in use for several years. They are made in the form of 60-degree prisms to provide for accurate measurements by the method of minimum deviation. By grinding and polishing a small area near one edge each prism is so modified [1] that a 90-degree intersection between polished faces is effected, and thus the prism may be used as a test slab on any refractometer provided the cement or metal in which a refractometer block is mounted does not project above the plane of the polished surface of the glass block. The faces of these prisms are of three sizes, 10 by 25, 12 by 30, and 24 by 24 mm. Small size of face is of particular importance whenever the cement or metal does project above the glass block.

The glasses for these prisms were purchased through two or three different agencies but were, perhaps, all made at Jena, Germany. These prisms represent as many as six, and possibly seven, separate melts of glass. The data for glass A depend on only one prism but for the other glasses the data are averages for duplicate prisms. Glass A is somewhat lower in index than any now listed in the Schott & Gen. catalog. Glass B was purchased in the United States and glass C procured directly from Jena, but they differ so little that these two glasses may be originally from the same melt. Accordingly, their data have been averaged. Certainly glasses B and C closely resemble the Schott glass 0.7185 or, as more recently designated, FK3. Glass D corresponds to Schott's old designation 0.6500, or FK1. Glass E differs from the others included in this study and may not be a fluorcrown glass. It resembles the more usual silica glasses in that it has a decidedly positive temperature coefficient of refractive index. It is almost identical with Schott's FK4, which, in turn, however, is almost identical with their old designation 0.3258 that was styled "Borosilikat Cron," without reference to fluorine. Incidentally, Schott's FK4 is omitted in Glastechnische Tabellen (Berlin 1932) where, on page 314, the fluorcrown glasses FK1, 2, 3, and 5 are listed. Glass F is probably very similar to Schott's FK2 and to FK5; glass G appears almost identical with their old designation 0.6781.

[1] See illustration, p. 623, BS J. Research 3 (1929) RP112; also p. 372, J. Opt. Soc. Am. 32 (1942).

III. REFRACTIVE-INDEX DATA

Refractive-index data on these standard prisms are given in tables 1 to 6. The measurements were made by the method of minimum deviation on a spectrometer with a special constant-temperature prism housing that has been described in a former paper.[2] A feature of the work on these prisms with this apparatus is the determination of their temperature coefficients of index by precise observations at temperatures near those at which the standards are to be used. Although the imprecision of these observed data is about $\pm 13 \times 10^{-7}$, it is thought that the graduated data as tabulated are precisely smoothed to about $\pm 2 \times 10^{-7}$, except at the corners of the tables.

TABLE 1.—*Temperature variations in refractivity of fluorcrown glass (A), the values being smoothed by the item-differences method; average imprecision, observed minus smoothed index, is* $\pm 12 \times 10^{-7}$

$[\Delta n = (n_{t_2} - n_{t_1}) \times 10^7]$

Heavy rules in Δn columns are located approximately opposite the temperatures of minimum index.

Temperature (° C)	Refractive index (referred to dry air at t° C and pressure of 760 mm of Hg)								Dispersion	
	λ=6562.8 A		λ=5893 A		λ=4861.3 A		λ=4340.5 A			
	n_C	Δn for 1° C	n_D	Δn for 1° C	n_F	Δn for 1° C	$n_{G'}$	Δn for 1° C	$\nu = \frac{n_D - 1}{n_F - n_C}$	$\Delta \nu$ for 1° C
55	1.4590118		1.4610931		1.4659489		1.4697922		66.468	
		+3.4		+4.8		+6.3		+9.2		−0.0027
50										
45	1.4590084		1.4610883		1.4659426		1.4697830		66.495	
		−0.9		+0.7		+2.7		+7.2		−.0034
40										
35	1.4590093		1.4610876		1.4659399		1.4697758		66.529	
		−2.9		−1.2		+1.0		+5.5		−.0038
30										
25	1.4590122		1.4610888		1.4659389		1.4697703		66.567	
		−5.0		−3.3		−1.3		+3.3		−.0036
20										
15	1.4590172		1.4610921		1.4659402		1.4697670		66.603	

TABLE 2.—*Temperature variations in refractivity of fluorcrown glasses (B and C) resembling Schott & Gen. FK3 or 0.7185 (values smoothed by the item-differences method from averaged data on four prisms; average imprecision, observed minus smoothed index, is* $\pm 8 \times 10^{-7}$)

$[\Delta n = (n_{t_2} - n_{t_1}) \times 10^7]$

Temperature (° C)	Refractive index (referred to dry air at t° C and pressure of 760 mm of Hg)								Dispersion	
	λ=6562.8 A		λ=5893 A		λ=4861.3 A		λ=4340.5 A			
	n_C	Δn for 1° C	n_D	Δn for 1° C	n_F	Δn for 1° C	$n_{G'}$	Δn for 1°.C	$\nu = \frac{n_D - 1}{n_F - n_C}$	$\Delta \nu$ for 1° C
55	1.4601175		1.4622202		1.4671402		1.4710567		65.818	
		−13.7		−12.3		−10.0		−6.4		−0.0036
50										
45	1.4601312		1.4622325		1.4671502		1.4710631		65.854	
		−17.1		−16.3		−14.8		−10.1		−.0024
40										
35	1.4601483		1.4622488		1.4671650		1.4710732		65.878	
		−18.4		−17.7		−16.4		−11.5		−.0021
30										
25	1.4601667		1.4622665		1.4671814		1.4710847		65.900	
		−18.6		−17.9		−16.6		−11.7		−.0021
20										
15	1.4601853		1.4622844		1.4671980		1.4710964		65.921	

[2] J. Research NBS **17**, 389(1936) RP919.

TABLE 3.—*Temperature variations in refractivity of fluorcrown glass (D) resembling Schott & Gen.* FK1 *or 0.6500 (values smoothed by the item-differences method from averaged data on two prisms; average imprecision, observed minus smoothed index, is* $\pm 14\times10^{-7}$).

$[\Delta n=(n_g-n_h)\times10^7]$

Heavy rules in Δn columns are located approximately opposite the temperatures of minimum index.

Temperature (°C)	Refractive index (referred to dry air at t°C and pressure of 760 mm of Hg)																Dispersion	
	λ=7065.2 A		λ=6562.8 A		λ=5893 A		λ=5875.6 A		λ=4861.3 A		λ=4358.3 A		λ=4340.5 A		λ=4046.6 A			
	n	Δn for 1°C	n_C	Δn for 1°C	n_D	Δn for 1°C	n_d	Δn for 1°C	n_F	Δn for 1°C	n_e	Δn for 1°C	$n_{G'}$	Δn for 1°C	n_h	Δn for 1°C	$\nu=\frac{n_D-1}{n_F-n_C}$	$\Delta\nu$ for 1°C
55	1.4070671		1.4083528		1.4704657		1.4705277		1.4753922		1.4791364		1.4792990		1.4822206		66.833	
50		−1.5		−0.9		+0.1		+0.5		+1.5		+2.2		+2.5		+2.8		−0.0023
45	1.4070066		1.4083537		1.4704656		1.4705272		1.4753907		1.4791342		1.4792974		1.4822178		66.856	
40		−3.7		−3.1		−3.7		−3.3		−1.5		+0.4		+0.8		+2.2		−.0035
35	1.4071043		1.4083588		1.4704693		1.4705305		1.4753922		1.4791338		1.4792966		1.4822156		66.891	
30		−9.0		−8.3		−6.4		−5.9		−3.5		−1.0		−0.2		+1.9		−.0046
25	1.4071133		1.4083671		1.4704757		1.4705364		1.4753957		1.4791348		1.4792968		1.4822137		66.937	
20		−10.7		−9.9		−7.6		−7.0		−4.4		−1.7		−.6		+1.7		−.0084
15	1.4071240		1.4083770		1.4704833		1.4705434		1.4754001		1.4791365		1.4792974		1.4822120		66.991	

TABLE 4.—*Temperature variations in refractivity of "fluorcrown" glass (E) resembling Schott & Gen.* FK4 *or 0.3258 (values smoothed by the item-differences method from averaged data on two prisms; average imprecision, observed minus smoothed index, is* $\pm 10\times10^{-7}$)

$[\Delta n=(n_{t_2}-n_{t_1})\times 10^7]$

Temperature (° C)	Refractive index (referred to dry air at t° C and pressure of 760 mm of Hg)								Dispersion	
	λ=6562.8 A		λ=5893 A		λ=4861.3 A		λ=4340.5 A			
	n_C	Δn for 1° C	n_D	Δn for 1° C	n_F	Δn for 1° C	$n_{G'}$	Δn for 1° C	$\nu=\frac{n_D-1}{n_F-n_C}$	$\Delta\nu$ for 1° C
55	1.4768290		1.4790285		1.4841205		1.4881473		65.697	
		+51.1		+54.4		+56.9		+57.4		−0.0045
50	1.4767779		1.4789741		1.4840636		1.4880899		65.742	
		+44.5		+47.0		+49.9		+53.6		−0.0042
45	1.4767334		1.4789271		1.4840137		1.4880363		65.784	
		+41.1		+42.9		+46.0		+53.3		−0.0038
40	1.4766923		1.4788842		1.4839677		1.4879830		65.822	
		+41.1		+42.8		+45.8		+53.2		−0.0037
35	1.4766512		1.4788414		1.4839219		1.4879298		65.859	

TABLE 5.—*Temperature variations in refractivity of fluorcrown glass (F) resembling Schott & Gen.* FK2 *and* FK5 *(values smoothed by the item-differences method from averaged data on two prisms; average imprecision, observed minus smoothed index, is* $\pm 21\times10^{-7}$)

$[\Delta n=(n_{t_2}-n_{t_1})\times 10^7]$

Temperature (° C)	Refractive index (referred to dry air at t° C and pressure of 760 mm of Hg)								Dispersion	
	λ=6562.8 A		λ=5893 A		λ=4861.3 A		λ=4340.5 A			
	n_C	Δn for 1° C	n_D	Δn for 1° C	n_F	Δn for 1° C	$n_{G'}$	Δn for 1° C	$\nu=\frac{n_D-1}{n_F-n_C}$	$\Delta\nu$ for 1° C
55	1.4878154		1.4899206		1.4948144		1.4988899		69.999	
		−17.0		−15.3		−13.6		−10.6		−0.0036
50	1.4878324		1.4899359		1.4948280		1.4987005		70.035	
		−17.7		−16.1		−14.5		−11.7		−0.0034
45	1.4878501		1.4899520		1.4948425		1.4987122		70.069	
		−18.0		−16.4		−14.9		−12.1		−0.0034
40	1.4878681		1.4899684		1.4948574		1.4987243		70.103	
		−18.1		−16.5		−15.0		−12.3		−0.0033
35	1.4878862		1.4899849		1.4948724		1.4987366		70.136	

TABLE 6.—*Temperature variations in refractivity of fluorcrown glass (G) resembling Schott & Gen. 0.6731 (values smoothed by the item-differences method from averaged data on two prisms; average imprecision, observed minus smoothed index, is* $\pm 15\times10^{-7}$)

$[\Delta n=(n_{t_2}-n_{t_1})\times 10^7]$

Temperature (° C)	Refractive index (referred to dry air at t° C and pressure of 760 mm of Hg)								Dispersion	
	λ=6562.8 A		λ=5893 A		λ=4861.3 A		λ=4340.5 A			
	n_C	Δn for 1° C	n_D	Δn for 1° C	n_F	Δn for 1° C	$n_{G'}$	Δn for 1° C	$\nu=\frac{n_D-1}{n_F-n_C}$	$\Delta\nu$ for 1° C
5	1.4910265		1.4931528		1.4980910		1.5019926		69.807	
		−19.1		−17.2		−15.4		−14.1		−0.0039
0	1.4910456		1.4931700		1.4981064		1.5020067		69.846	
		−19.7		−17.7		−15.9		−14.4		−0.0040
5	1.4910653		1.4931877		1.4981223		1.5020211		69.886	
		−20.0		−17.9		−16.0		−14.5		−0.0042
0	1.4910853		1.4932056		1.4981383		1.5020356		69.928	
		−20.2		−18.0		−16.1		−14.6		−0.0044
5	1.4911055		1.4932236		1.4981544		1.5020502		69.972	

The tabulated data extend over a near-room range of temperatures, at which water-jackets are commonly used, because the temperature coefficients of the refractometers on which such standards may be used are seldom, if ever, adequately known. This is a matter of primary importance for an instrument which, like the Butyro refractometer, is to be used at relatively high working temperatures on fats and waxes, some of which are solids at ordinary room temperatures. In such cases it is recommended that refractometers be adjusted on solid samples at the working temperature in use. In this way one obviates corrections relative to a known performance at standard temperature.[3] Some fluorcrown glasses seem especially suitable for these standards because their temperature coefficients of refractivity are negligibly small. Glasses A and D have their minima of refractivity at room temperatures. The temperatures differ for various wavelengths and are indicated approximately by the rules in the Δn columns of tables 1 and 3. The refractive-index data here given will facilitate the making of refractive-index standards from similar glasses by greatly reducing the number of precise index measurements that will be required in their calibration over a suitable range of temperatures.

IV. SURFACE INSTABILITY

The use of fluorcrown glasses for refractive-index standards is, however, not entirely satisfactory. Unfortunately, many of them are relatively soft and the polished surfaces are easily scratched. In some cases there is a far more serious tendency to weather or disintegrate in such manner that the surface changes its refractive index and no longer corresponds to the index of the main body of the glass as measured on the spectrometer. Whenever this occurs, repolishing is imperative. The effect of weathering may first be noticed as a poorly defined critical border or residual chromaticity when one attempts to use the compensator. Later, as a more striking manifestation, multiple critical borders are seen. These correspond apparently to different glasses in different parallel layers near the surface. For the glass A, of index 1.4611, the lowest here considered, it is found that repolishing is necessary after a very few months. After a period of 2 years the glass D, index 1.4705, showed some indications of surface index changes and the glasses B and C, index 1.4623, presented slight evidence of this sort. In both these cases the changes were unmistakable after 5 years. For the other glasses no changes were optically detectible after 9 years. One surface of each prism was resurfaced after 7 years, but it is not certain that this was necessary in any case (except for the 1.4611 glass) for their accurate use in refractometry with a precision of ± 1 or 2×10^{-5} as the maximum probable error in index determinations. Nevertheless, experience with these standards suggests that it is advisable to test the stability of fluorcrown glasses before precise calibrations are undertaken.

The optical evidences of the changes that take place on and near the surfaces of the prisms of glasses A, B, C, and D are so nearly systematic in their approximate regularity and interrelations that a detailed report thereon is given in table 7 and figure 1. Possibly there are only

[3] See the author's discussion of temperature effects in critical-angle refractometry, J. Research NBS 30 317 (1943) RP1535.

TABLE 7.—*Refractometric measurements on products formed by surface weathering of fluorcrown optical glasses*

Critical border line	Glass A			Glass B=C				Glass D				
	*1938	1944	n_F-n_C	*1938	1942	1944	n_F-n_C	*1938	1940	1942	1944	n_F-n_C
Principal	1.4611	1.4611	0.0069	1.4622	1.4622	1.4622	0.0070	1.4705	1.4705	1.4704	1.4704	0.0070
	1.4622	----	.0082	----	----	1.4636	.0082	1.4718	1.4720	1.4726	1.4727	.0080
First bright-line "doublet"	1.4626	----	----	----	1.4636	1.4638	----	1.4723	1.4723	1.4728	1.4730	----
	1.4634	1.4648	.0081	1.4649	----	1.4655	.0080	1.4737	1.4766	1.4770	1.4771	.0083
Second bright-line "doublet"	----	1.4651	.0081	----	1.4657	1.4659	----	1.4773	1.4774	1.4773	1.4776	----
Third bright-line "doublet"	1.4708	----	----	1.4676	----	1.4682	.0084	----	----	----	----	----
	----	----	----	----	1.4694	1.4696	----	----	----	----	----	----
Fourth bright-line "doublet"	----	----	----	1.4722	----	1.4722	.0089	----	----	----	----	----
	----	----	----	----	1.4729	1.4729	----	----	----	----	----	----

* Numerous measurements of n_D made from 1929 to 1938 on various critical-angle refractometers were averaged.

The tabulated data extend over a near-room range of temperatures, at which water-jackets are commonly used, because the temperature coefficients of the refractometers on which such standards may be used are seldom, if ever, adequately known. This is a matter of primary importance for an instrument which, like the Butyro refractometer, is to be used at relatively high working temperatures on fats and waxes, some of which are solids at ordinary room temperatures. In such cases it is recommended that refractometers be adjusted on solid samples at the working temperature in use. In this way one obviates corrections relative to a known performance at standard temperature.[3] Some fluorcrown glasses seem especially suitable for these standards because their temperature coefficients of refractivity are negligibly small. Glasses A and D have their minima of refractivity at room temperatures. The temperatures differ for various wavelengths and are indicated approximately by the rules in the Δn columns of tables 1 and 3. The refractive-index data here given will facilitate the making of refractive-index standards from similar glasses by greatly reducing the number of precise index measurements that will be required in their calibration over a suitable range of temperatures.

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Principal	1.4611	1.4611	0.0069	1.4622	1.4622	1.4622	0.0070	1.4705	1.4705	1.4704	1.4704	0.0070
First bright-line "doublet"	1.4622	----	.0063	----	----	1.4636	.0082	1.4718	1.4720	1.4726	1.4727	.0060
	1.4626	----	----	----	1.4636	1.4638	----	1.4723	1.4723	1.4728	1.4730	----
Second bright-line "doublet"	1.4654	1.4648	.0081	1.4649	----	1.4655	.0086	1.4767	1.4766	1.4770	1.4771	.0083
	----	1.4651	.0081	----	1.4657	1.4659	----	1.4773	1.4774	1.4773	1.4776	----
Third bright-line "doublet"	1.4706	----	----	1.4676	----	1.4682	.0084	----	----	----	----	----
	----	----	----	----	1.4684	1.4686	----	----	----	----	----	----
Fourth bright-line "doublet"	----	----	----	1.4723	----	1.4722	.0089	----	----	----	----	----
	----	----	----	----	1.4729	1.4729	----	----	----	----	----	----

• Numerous measurements of n_D made from 1929 to 1938 on various critical-angle refractometers were averaged.

a limited number of relatively stable glasses of the fluorcrown type, and after weathering takes place the surface layer may change to some one of the relatively stable glasses that are higher in index. Moreover, this process seems capable of sluggish progression so that one test prism sometimes gives not only the principal border line but as many as eight faint critical edges, simultaneously visible, and some of them are found to correspond approximately to the border lines seen with other glasses of higher index.

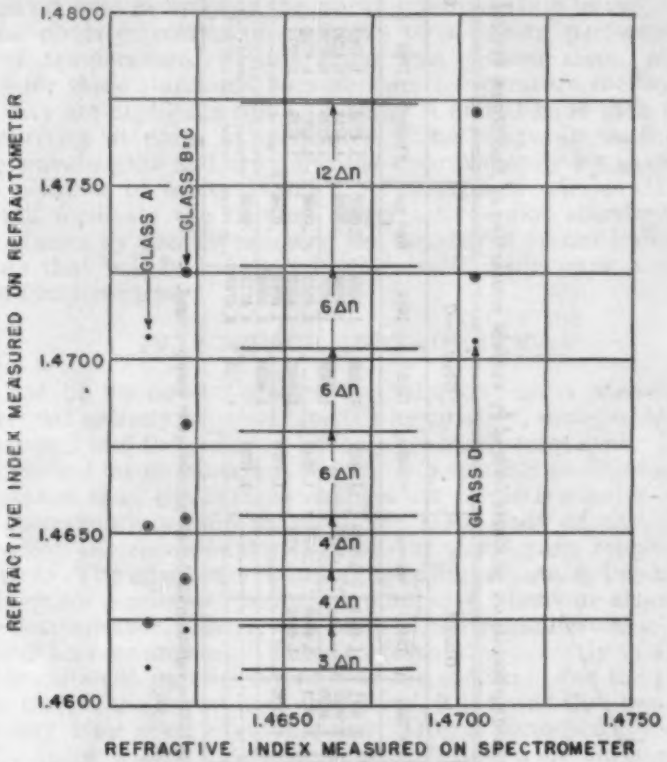

FIGURE 1.—*Refractivity of three fluorcrown optical glasses and of the products formed by their surface weathering.*

Numerous measurements of n_D made from 1929 to 1944 on various critical-angle refractometers were averaged. Encircled points represent averages for two distinct critical borderlines. The average separation of the "doublets" in these eight instances is $\Delta n = 0.0004$.

It is reasonable to suppose that loss of fluorine is an important element in the weathering process, and in this connection it should be noted that the dispersion, $n_F - n_C$, for all of the weathered layers is found to be as high as 0.0080 to 0.0090, whereas that of the main body of these glasses is only 0.0070. In fact, the dispersions of the weathered layers approximate those of lowest-index silicate glasses without fluorine.

The only added critical edges that can be readily observed in the field of a refractometer, together with the edge corresponding to the main volume of the glass, are those corresponding to surface layers of *higher* index. These edges appear in the otherwise dark portion of the field. Each thin layer on the sample surface gives a narrow-slit

effect and confines the brightly illuminated area to a narrow line of which one side is a critical border and the other is a geometrical limit imposed by the width of the layer.

This interpretation of the observed phenomena was confirmed by observations on a composite prism made by cementing thin layers of different-index glasses on the surface of a standard sample. Also, similar phenomena were observed on two crown-flint prisms (n_D= 1.5296) that, after polishing, were annealed in a new furnace where lead oxide was inadvertently present on some of the iron plates. Three added critical edges were well-defined for the *C*, *D*, and *F* lines, and they corresponded to layers having indices $n+\Delta n$, $n+2\Delta n$, and $n+4\Delta n$, where $\Delta n=0.00004$ and differences in dispersion, if any, were too small to be detected.

Remembering that these glasses A, B=C, and D, which are found to exhibit this multiple-index behavior, resemble the Schott glasses FK1 and FK3 in their index and dispersion, it is interesting to note from the meager data on compositions, as given on page 314 of Glastechnische Tabellen, that these fluorcrowns FK1 and FK3 differ from FK2 and FK5 in that they contain aluminum.

It is not implied that the multiple edges observed on some of these glasses are necessarily present when other similar glasses are used. In fact, three prisms of unknown antecedents, having indices of 1.46541, 1.47952, and 1.49776, showed no multiple edges when examined. They had been surfaced at least 3 months when tested, but no more definite knowledge concerning them is now obtainable. It is possible, also, that some improvements in the weathering characteristics of the fluorcrown glasses have been effected by the manufacturers in recent years. Nevertheless, there is probably in existence much unused glass of melts like those cited in this report. Consequently, care should be exercised by refractometrists when fluorcrown glasses are selected or used for standards in precise refractometry.

V. EFFECT OF TEMPERATURE ON RESONANCE FREQUENCY

Entirely aside from their value in refractometry, the data given in tables 1 to 6 are of theoretical interest because of their evidence regarding the effect of temperature on the resonance frequencies of vibration in the ultraviolet region. With the exception of glass E, these glasses differ from most optical glasses in that their temperature coefficients of refractive index are, in general, negative. In this respect they resemble liquids and most crystals. In such cases the normal effect of temperature on density is said to predominate over that ascribed to shifting of the absorption band as temperature changes.

Tables 1 and 3 and figure 2 show that the condition for zero temperature coefficient of index in these glasses is a function of temperature and of wavelength, so that the minimum of change in index can in some cases, as for glass D, occur near 55° for red light, near 35° for blue, and well below 15° for violet light. Obviously, at higher temperatures all these glasses can be expected to have positive temperature coefficients of refractive index as do optical glasses in general. In all cases for these data the temperature coefficients of index increase algebraically (1) as the temperature increases and (2) as wavelength is shortened, just as should be the case if the critical frequency becomes lower when the temperature rises. From figure 2

it is evident that in some cases wholly erroneous conclusions regarding the temperature coefficients of crown glass at room temperatures may easily be drawn from index data taken on glass over a wide interval from room to furnance temperatures.

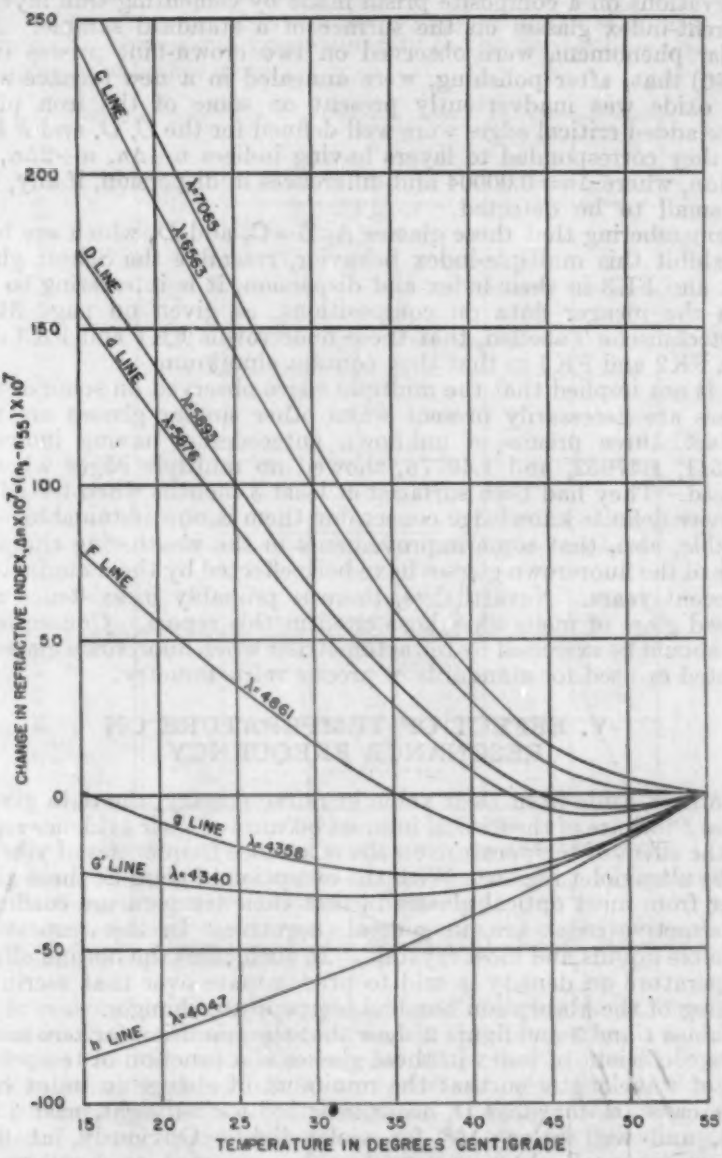

FIGURE 2.—*Minimum refractive index of a fluorcrown glass as a function of temperature and wavelength (data from table 3).*

For light of wavelength λ=4047 A this glass has a positive temperature coefficient of refractivity at all room temperatures as indicated by the positive slope of the lowest curve, whereas for λ=7065 A the coefficient is negative. For most intermediate wavelengths, there is a zero slope and a minimum refractivity at some near-room temperature.

WASHINGTON, February 10, 1945.

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